THURSDAY, FEBRUARY 21, 1901.

THE GENESIS OF ART.

The Origins of Art; a Psychological and Sociological Inquiry. By Yrjö Hirn. (London: Macmillan and Co., Ltd., 1900.) Price 10s. net.

THE various studies usually grouped under the general term of Anthropology are slowly but surely extending their scope. Not very long ago art was considered to be beyond the realm of science, and its exposition was mainly in the hands of art-critics; but of late years scientific methods have been employed to discover why works of art are created and why they are enjoyed, and to trace the modifications which they have undergone. Those who have paid attention to the subject have recognised, with Bastian, that art is a branch of psychology, and Herbert Spencer and Grosse have also laid stress on the immense importance of art in the evolution of human societies. It is therefore with great pleasure that we welcome an investigation into the origins of art from a psychological and sociological point of view by the learned Finnish savant, Dr. Yrjö Hirn.

Even a casual glance at this clearly and brightly written book will demonstrate that the author has assimilated a mass of information gained from a wide range of reading. A more careful perusal shows that he handles his facts judiciously, and keeps himself well in hand. The deductions are lucidly stated, and the authority for each statement of fact is quoted; the reader has, therefore, every facility for traversing an argument should it not appear at first sight to be valid.

To those who have a fair knowledge of the culture of primitive peoples the book will prove very suggestive, as new light will be thrown upon many well-known facts, and isolated observations will be brought into line.

In the following summary of the main arguments of the book the author's own words have been largely employed, which also will assist towards giving a more complete conception of the work. It is perfectly safe to prophesy that this book will prove of very great value not only to the student at home, but to the investigator in the field.

Despite the generally received dictum of "art for art's sake" it will often be found, especially among primitive folk, that some form of interest, personal, political, ethical or religious, enters into what is regarded as disinterested æsthetic activity. In almost every case where the ornaments of a tribe have been closely examined, it has appeared that what seems to us a mere embellishment is for the natives full of practical, non-æsthetic significance, such as religious symbols, owners' marks, or ideograms, and it is surprising what religious or magical significance lies concealed behind the most apparently trivial of amusements. The dances, poems, and even the formative arts of the lower races possess unquestionable æsthetic value; but this art has generally a utility, and is often even a necessity of life.

The play-theory of Groos, although it unquestionably is explanatory of a great deal, does not account for the origin of the artistic impulse. The aim of play is attained when the surplus vigour is discharged, or the instinct has had its momentary exercise; but the function of art is not confined to the art of production; something is made and something survives. Excitement and intense delight manifest themselves in movement, dances and songs which rather relieve incipient pain than express pleasure, violent movement acting rather as a regulator by which the organism restores itself to its natural state. By the control of the bodily movements, which form its simplest expression, joy may be diverted into the region of thought.

While supplying man with a means of intensifying all his varied feelings, art at the same time bestows upon him that inward calm in which all strong emotions find their relief. It is very difficult for an individual to resist the contagion of collective feeling, and all strong feelings act as socialising factors. A work of art is the most effective means by which the individual is enabled to convey to wider and wider circles of sympathisers an emotional state similar to that by which he is himself dominated.

Grosse and Wallaschek have emphasised the important part rhythm has played in the struggle for existence by facilitating co-operation, and the contagious power of an idea is vastly increased when it is cast in rhythmical form, whether it be the gymnastic dance, unmelodious music, poetry, or decorative art. Later, owing to more complex emotions, simple gymnastic dancing becomes pantomimic, and the drama is evolved. A histrionic element also manifests itself in other forms of artistic production—for example, literature and the formative and decorative arts of design. With the increased importance of the intellectual elements accompanying the emotional states, direct emotional suggestion appears an inadequate means of communication; and in ornament and music, as well as in painting and novels, there will be found an imitation of nature which serves what, in the widest use of the term, may be called an epic purpose.

In the endeavour to secure the transmission and perpetuation of a feeling, the expressional activity gradually loses its purely impulsive character and becomes transformed into deliberate artistic production which is conscious alike of its aim and of the means for attaining it. The more the work grows in definiteness in the thought and under the hand of the artist, the more it will repress and subdue the chaotic tumult of emotional excitement.

The art impulse, in its broadest sense, must be taken as an outcome of the natural tendency of every state of feeling to manifest itself externally, the effect of such a manifestation being to heighten the pleasure and relieve the pain.

Various other influences have all along been at work which have determined the concrete forms of art. Groos has rightly laid stress on the play-impulse, which has been of incalculable importance in the history of art; but there are also, for example, the impulse to attract by pleasing and the imitative impulse. Dramas may have been composed, pictures painted, or poems made in play, or out of a desire to please, or out of an inborn taste for mimicry.

Among primitive peoples, the dance, the pantomime, and even ornament, have been of great importance as means for the dissemination of information. Although

there is but one step between the impromptu dance or poem which tells of a recent occurrence and the work of art which transmits the memory of that occurrence to posterity, yet it appears that there are savages who have no historical art. On the other hand, the historical art has everywhere reached its highest state of development amongst nations who have had to hold their own against neighbouring tribes.

Before discussing the problems of art and sexual selection, of the origin of self-decoration and of erotic art, the author devotes a chapter to a consideration of animal display, and his treatment of the subject is worthy of the attention of zoologists. He arrives at the conclusion that human sexual selection did not create any quality of beauty and that human decoration, like that of animals, is mainly an advertisement of likeness of kind; but, strange as it may appear, scarcely any form of dress or ornament can be quoted which could be considered with certainty an outcome of the impulse to attract or charm the opposite sex. Decorations of various kinds are conferred on young people on attaining puberty, and indicate a new social status, and various subsequent advances in rank have their appropriate decoration. The impulse to ostentation with regard to rank, valour or wealth is undeniably independent of sexual selection. Even where there is no competition between rivals, sexual emotions may still find an artistic expression. Like the courting display of many birds, men may have resorted to song and dance as a mode of overcoming the instinctive coyness of the female after sexual selection has operated; but the strong emotional tension of such periods must in any case seek relief by sound or movement.

It is evident that a pantomimic imitation of any activity must, as exercise and stimulation, facilitate the subsequent real execution of the same activity. Individuals and nations who have grown familiar in play with the most important actions in life's work have thus acquired an unquestionable advantage in the struggle for existence. This holds good alike for the everyday occupations of life as for war. Music and song have especially been useful stimuli to work, partly to overcome natural laziness or inertia, partly to effect unison in the actions of several workers; for instance, the regularity of the action of many peoples is explicable as a result of the rhythmical songs by which their work is accompanied. This applies with equal force to war; hence it is not surprising to find highly developed choral dances in those peoples in whose life war is a customary occurrence. The need of stimulation is never so great as when a man has to risk his life in an open battle, and with this end in view the military singers of some tribes are able to work themselves and their audience up to a pitch of frenzy which is almost equal to that produced by the dances. Courage is also induced by the effort to appear formidable and courageous. Instruction in grimacing even formed a part of the military education of the Maoris. Hence, too, the frightful decorations which so many peoples employ when going on the warpath and the well-known face-shields of some of the tribes of New Guinea and Borneo. The decorative art of warlike peoples is usually characterised by a vigour and originality which dominate also their poetry and dramatic dances, and which are the outcome of an intense and forcible life; but descriptive and figurative art, in the sense of realistic, faithful rendering of nature and life, has never attained any high development among the most military tribes.

Sympathetic magic which is based upon a likeness between things calls forth imitations of nature and life which, although essentially non-æsthetic in their intention, may nevertheless be of importance for the historical evolution of art. Nor is this confined to the primitive or decorative arts. There are many magical dances and pantomimes, and there is an universal belief in the efficacy of incantations and in magical songs and poems.

Every man seeks automatically to heighten his feelings of pleasure and to relieve his feelings of pain. The artist is the man who finds that he can gain such enhancement or relief, not only by the direct action of giving expression to his feeling, but also by arousing a kindred feeling in others. Hence originates in him that desire to transmit his moods to an external audience, and there also arises the endeavour to give the artistic product a form which may facilitate the revival of the original state in an ever-widening circle of sympathisers.

"Beyond the fact that art has been obliged to avail itself of media which have originally been called into existence by utilitarian, non-æsthetic needs, there lies another fact. To these external 'origins' we can also trace some of the most important qualities which we appreciate in a work of art. In this way it is open to us to explain how several of the virtues of art, as we know it, may be derived from the primitive needs which it subserved; how, for instance, the lucidity of art may find its explanation in art's use for conveying information; how the sensuous and attractive qualities of all art may be traced to the need for propitiating favour; how the power that resides in art to trace and stimulate the mind may be transmitted from the days when the artist was appointed to nerve his fellows for work or war. And, lastly, it might be argued that a most characteristic quality of art—the imagination—which is in a sense faith in the reality of the unreal, may have been immensely heightened by the use of art for purposes of magic, which fuses the visible and the invisible."

ALFRED C. HADDON.

THE PARTIAL DIFFERENTIAL EQUATIONS OF MODERN MATHEMATICAL PHYSICS.

Die Partiellen Differentialgleichungen der mathematischen Physik. Nach Riemann's Vorlesungen. Fourth edition. Revised and rewritten by Heinrich Weber. Vol. i. Pp. xvii + 506. (Brunswick: Friedrich Vieweg und Sohn, 1900.)

THE lectures, delivered at the University of Göttingen by Prof. Bernard Riemann in the sessions of 1854-55, of 1860-61 and in the summer of 1862, have, thanks to the volume brought out after Riemann's death under the editorship of Karl Hattendorff, long ranked among the mathematical classics. The third and last edition of "Partielle Differentialgleichungen" appeared in 1882, and two years ago Prof. Heinrich Weber was entrusted with the task of bringing out a fourth

edition. There were three possible ways in which this task could have been fulfilled. One way was to republish the edition of 1882, with trifling additions and alterations. The second way was to retain the existing text, but to add copious notes together with references to recent developments bordering on the subject of Riemann's lectures. The third way was to write an entirely new book, based, indeed, on the earlier editions, but completely brought up to date by the embodiment of the new methods and problems that have come into existence in connection with discoveries in mathematics and physics extending over nearly twenty years from the date of the last edition, and nearly forty years from the time when the lectures were given by Riemann.

Prof. Weber has adopted the last of these alternatives, and by so doing has produced a treatise which will be invaluable to the modern mathematical physicist. How far the present treatise is to be regarded as a new work written by Prof. Weber may be inferred from the fact that this, the first volume only, covers 506 pages, as compared with a total of 325 in Hattendorff's edition, and all the last 350 pages are new.

The first part, dealing with analytical methods, corresponds more or less closely with the first three sections of Hattendorff's edition. It deals with definite integrals, infinite series and the differential equations of common occurrence in physics, especially linear equations with constant coefficients. In this portion we are indebted to Prof. Weber for an amplification of the treatment of Fourier's series and Fourier's double integral theorem, for a more precise treatment of continuity and for entirely new sections dealing with surface and volume integrals, functions of complex variables and conformal representation, and Bessel's functions, the last named addition occupying forty pages.

The second part is entirely new. In it Prof. Weber discusses linear infinitesimal deformations and then gives us a chapter on vectors, in which the modern notions of "curl" and "divergence" are fully explained, and expressions for the curl of a vector given in orthogonal coordinates. This is followed by sections on theory of the potential, including Green's theorem and potentials of ellipsoids. The next section deals with spherical harmonics, and this is followed by a short summary of the principles of dynamics, including the Hamiltonian equations and least action.

The only branches of physics treated in Hattendorff's edition were conduction of heat, elasticity (including vibrations) and hydrodynamics. The absence of any reference to electricity and magnetism is accounted for by the fact that these subjects, together with gravitation, were treated by Riemann in a separate course, of which an edition was also prepared for press by Hattendorff in 1876. The third part of the present volume forms a treatise on the mathematical theory of electricity and magnetism, for which Prof. Weber is thus solely responsible. The fundamental principles of electrostatics and magnetism are based on the hypothesis of a continuous medium, the electrical and magnetic properties of which depend on the existence at every point of space of certain vector quantities satisfying stated laws; and the subject is thus introduced much after the manner adopted by Hertz. Among the problems depending for their solution upon the method of conformal representation, we notice an application of the transformation of Schwarz and Christoffel to the distribution of electricity on a prism, an example which practically amounts to an exposition of this transformation.

The subject of contact electricity, too, receives ample mathematical treatment. Perhaps, however, the most interesting sections are those dealing with electrolysis; and this interest is largely due to the important part which Prof. Weber himself has played in advancing our theories of this difficult subject. A comparison of these sections, in which the problem of electrolysis is made to depend on the solution of differential equations which Weber integrates in certain special cases, with the fragmentary information contained in text-books of forty years ago, is sufficient indication of the progress which has been made during the past half century in developing new fields of study in applied mathematics, and in coordinating and perfecting the mathematical treatment of electricity.

Steady flow of electricity, and the fundamental principles of "electrodynamics" (as it used to be and still sometimes is called), occur in their proper places in the present volume. No mention, however, is made of Hertzian oscillations, which are to be dealt with in the forthcoming second volume in connection with the theory of oscillations in general. The remaining subjects to be treated in the latter volume include conduction of heat, hydrodynamics and elasticity.

Mathematicians will, of course, not be satisfied with the present treatment of such matters as convergence of series and of integrals, and on the other hand physicists will require to supplement the volume with other works containing a fuller consideration of the experimental aspect of the various theories. It was no purpose of Prof. Weber's to aim at completeness in either of these respects. The object of the book is rather to furnish a statement of results both in pure mathematics and in physics, and to indicate the methods by which the former results, used in conjunction with the latter, lead to the mathematical solution of physical problems. As an illustration of the spirit of the book, we may notice the article on semi-convergent series, where the use of these series is explained mainly by the consideration of an illustrative example. Again, as Prof. Weber points out, there are many physical problems which can only be solved by approximate methods of little or no mathematical interest, and these again are omitted.

Now a book of this character appeals to a considerable class of present-day physicists. Forty years ago physical laboratories hardly existed, and the pioneers of physics in this country were Cambridge wranglers who approached the subject from its mathematical side exclusively. Now that physical laboratories are scattered all over the country, and that the working man can attend science classes close to his own door, we are running to the opposite extreme, and there is an ever-increasing class of student who requires to master the mathematics required for his physical studies, but who starts his mathematical reading too late in the day to work up step by step from the very beginning. As was pointed out by Riemann

in the introduction reproduced in Hattendorff's first edition, a science of physics (or more literally "a scientific physics") first existed after the discovery of the differential calculus. A sound knowledge of the differential and integral calculus is assumed in this book, but in Germany such a knowledge is acquired by the majority of students at the commencement of their academic curriculum, a stage where, in this country, many students are still attending lectures on fractions, highest common factor and Euclid. Those possessing the necessary preliminary training will find in Weber's new edition of Riemann an excellent introduction to the methods of applying mathematical principles to the problems of modern physics.

G. H. B.

THE CLASSIFICATION OF EARS.

The Human Ear, its Identification and Physiognomy. By Miriam Anne Ellis. Pp. x+225. (London: A. and C. Black, 1900.) Price 3*s.* 6*d.* net.

A SIMPLE, workable, absolutely trustworthy system is still urgently wanted for the detection of criminals, and if the authoress of this book has succeeded she certainly deserves the thanks of all the Governments of Europe. Whatever worth her method may have when it comes to be applied practically, it has some decided drawbacks when the data are examined on which it is founded.

It so happened that about seven years ago the reviewer came to the conclusion that the external ear ought to yield some clue to the relationship of man and ape, and of one race of man to another. As is well known, the characters of the ear are fully inherited, and afford fairly trustworthy clues to family relationship, of which the authoress gives some good illustrations. Founding his method of observation and classification on data derived from a study of the development and comparative anatomy of the external ear, the reviewer proceeded to examine by hundreds the various peoples and races living on the shores of the North Sea, first on the Continental side, then on the British, to see how far the data he accumulated would support the semi-traditional accounts available concerning the early Saxon invasions of Britain. These observations were continued into the Highlands of Scotland, to Ireland and Wales. To test the "criminal-mark" theory of Lombroso and many others, he examined the ears of more than 800 confirmed criminals, and of more than two thousand inmates of asylums for the insane, situated in parts of the country where he had already examined the ears of the sane. Altogether the ears of more than 40,000 people of different races and of different moralities, besides those of about 300 apes and anthropoids, were examined, but the total results of this elaborate investigation were almost entirely of a negative nature.

The authoress appears to take it for granted, and evidently has not inquired into the matter, that the ear of the criminal is peculiar. If the reviewer's methods and observations are correct, the confirmed criminal's ear is the ear of the average inhabitant of Great Britain. Nor did the ears of the insane differ, on an average, from those of the people from which they were drawn, and if the authoress had carried her observations over a number of men of genius or of high ability, instead of drawing elaborate deductions from single observations, she would probably have arrived at a similar conclusion as to them.

The great difficulty in a matter of this kind is to arrive at a method of classification, and it is in this that all the systems propounded break down when applied practically, and the system propounded here is worse than those that have gone before it. In her classification, the first division is a separation of ears into (1) large; (2) medium; (3) small. Unfortunately, she proposes no definite measurements, but if she did it would be found that a great proportion of ears fell on the limits of the medium line, and it would be a matter of the greatest difficulty to say to which of the great divisions it belonged. There is another great obstacle to the application of measurement of the ear to detection of criminals, of which the authoress is unaware. As Schwalbe showed years ago, and as the authoress may verify any quiet half hour during sermon time, the ear, in the later decades of life, undergoes a very considerable growth—enough to shift the ear of a woman aged forty from the medium division to the large division when she is aged sixty.

The authoress has used one of the most variable and untrustworthy features of the human ear for the purpose of subdividing and indexing the forms in which it is found. She detects in its helix (the upper and posterior border of the ear) five divisions, separated by indentations more or less marked. The three great groups of large, medium and small ears are subdivided according to which and how many of these divisions of the helix are present. In many cases no two observers would agree as to the number of helical subdivisions present, which is not remarkable when it is remembered that the helix on the posterior border is a vestigial structure, the result of the infolding of the free margin of the ear. The amount of infolding does not indicate, as the authoress supposes, certain psychological peculiarities, but merely the degree of retrogression in the ear examined. Like all truly vestigial structures, the infolded margin of the helix is subject to such a variety of forms that it defies classification.

One or two interesting, although minor, points might also be mentioned. The statement that the length of the ear depends on the length of the nose, and that the measurement of the one is identical with that of the other, will be found, on trial, to be the exception and not the invariable rule. In most anatomical works the relation of the breadth to the length of the ear is used as a method of classification; quite a useless one, in the reviewer's opinion. The statement made here is that "the width of the pinna should be at its middle part exactly half its length. . . . Any deviation from these exact measurements at once forms a valuable aid in identification." The scientific part of this book was read in the Anthropological Section at the meeting of the British Association at Bristol in 1898, and many of the observations it contains were made on the ears of eminent men of science. The authoress proposes the term of "otomorphology" to cover the science of the external ear, but from the phrenological character given it by this work perhaps the name of "earistry" were better.

A. KEITH.

OUR BOOK SHELF.

Die moderne Entwicklung der elektrischen Principien. Fünf Vorträge von Prof. Dr. Ferd. Rosenberger. Pp. iii + 170. (Leipzig: Johann Ambrosius Barth, 1898.)

THESE lectures formed a course given to school teachers at Frankfort during the Easter vacation, 1897. Published in book form, they furnish an excellent, though brief, historical survey of the development of electrical theory during the past three centuries. Of all those who have aided in this development, probably none played a more important part than Faraday, for it was he who really laid the foundation of the immense structure of modern theory. This is fully recognised by the author of the present volume, who gives due prominence to the work of Faraday and its influence in the development of electrical principles.

The first two lectures are occupied with the various forms of fluid theory of electric action in vogue down to the early part of the nineteenth century. Beginning at the time of William Gilbert, who may be said to be the first to make any attempt at a physical explanation of electric attractions, we are led through a long series of writings extending to the time when Ampère stated the laws of the magnetic action of electric currents, and brought the subject into the state in which it was found by Faraday. The whole of the third lecture is devoted to the life and experimental work of Faraday, and the great change which he brought about in electrical theory by his introduction of the notion of lines of force. How Faraday's method was so successfully followed by Maxwell, Hertz and others is ably described in the fourth lecture. In an amusing section which here follows, and the significance of which is obvious, the author describes the astonishment of the inhabitants of Mars at the wonders of a railway system established there by an enterprising company of earth-folk, and the elaborate dynamical theories with which the wise men of that planet sought to explain the phenomenon. The fifth lecture contains some exposition of the fundamental principles of mechanics and their relations to electricity. The book is throughout written in very readable style, and its value is much enhanced by numerous extracts from original papers. With the exception of certain instances of misspelling, notably in extracts from English writings, it is free from inaccuracies.

The Birds of Africa. By G. E. Shelley. Vol. ii. Part 2. (London: R. H. Porter, 1900.)

IN this portion of his great undertaking, Captain Shelley commences with the genus Promerops and concludes with the pipits, so that he is still far from coming to the end of the Passerines. In the seven exquisite coloured plates with which it is illustrated, Mr. H. Gronvold fully maintains the high standard of their predecessors, and the text is as full and complete as in the earlier parts.

In his preface the author takes occasion to explain the somewhat unusual arrangement of the Passerines he has seen fit to adopt. "I begin," he writes, "with the Passeriformes and follow on with the Piciformes. The two families of these separate orders which appear to me most nearly allied are the swallows and the swifts, so as I end the Passeriformes with the Hirundinidæ it entails beginning the classification with the Oligomyodæ." This, of course, renders matters perfectly clear. But, we venture to think this half-hearted approximation of the swifts to the swallows is begging the question. Either they are nearly allied or they are not. If the former be the case, they should be placed in the same order. If the latter, the superficial resemblance between the two groups is entirely due to adaptation, and they should be kept as far apart as possible.

On this point we may quote from Prof. Newton ("Dictionary of Birds") that "it should be always and most clearly borne in mind that, though so like swallows in many respects, the swifts have scarcely any part of their structure which is not formed on a different plan; and, instead of any near affinity existing between the two groups, it can scarcely be doubted by any unprejudiced investigator that the Cypselidæ not only differ far more from the Hirundinidæ than the latter do from any other family of Passeres, but that they belong to what in the present state of ornithology must be deemed a distinct order."

While, therefore, we maintain that the author has been ill-advised in his departure from the ordinary classification of the Passerines, this in no wise detracts from the value of his work in other respects. R. L.

One Thousand Problems in Physics. By William H. Snyder, A.M., and Irving O. Palmer, A.M. Pp. 142. (Boston: Ginn and Co., 1900.)

THESE problems are simple numerical exercises, mostly of an elementary character, on hydrostatics, "tenacity and elasticity," statics and dynamics (including gravitation and pendulums), light, sound, heat, expansion of gases, magnetism and electricity. Such a collection of questions should be of much use for class-room exercises. The best way of learning the fundamental principles of elementary physics is undoubtedly to practise making numerical calculations with them, and the large number of questions will enable the book to be used with different classes. Many of the questions could almost be used as oral exercises.

A few questions strike us as being somewhat ambiguously stated. Thus: "A boat weighing 2 tons is moving at the rate of 10 miles per hour when the engine breaks. If the coefficient of resistance of the water is $\frac{2}{5}$, how far will the boat go before it stops?" Even if it is not considered necessary to specify the law of variation of the resistance with the velocity, the units in terms of which the coefficient of resistance expressed should be given, for the result will depend on whether this coefficient represents $\frac{2}{5}$ of a ton at a velocity of 1 mile per hour or $\frac{2}{5}$ of a pound at a velocity of 1 foot per second. Again: "Two strings 6 and 10 feet long, meeting at a point and making an angle of 60°, support a 50 lb. weight. What is the tension on each string?" Here the result depends, not on the lengths of the strings which are given, but on their separate inclinations to the vertical which are not given and cannot be found without further data. The teacher will have little trouble in avoiding these questions.

Peach-leaf Curl: its Nature and Treatment. By Newton B. Pierce. (*Bulletin* No. 20, U.S. Department of Agriculture; Division of Vegetable Physiology and Pathology.) Pp. 204; plates 30. (Washington, 1900.)

THE disease known as peach-leaf curl is due to a fungus called *Exoascus deformans* (Berk.), and seems to be more or less common and destructive wherever peach-trees are grown. It is almost confined to the peach and nectarine and their derivatives; and although its country of origin is uncertain, it has long been known in Europe, and latterly elsewhere. In some countries, as in New Zealand, it has almost extirpated the peach-tree of late years, while the losses from the disease in the United States are said frequently to amount to several thousand dollars annually. The volume before us deals with the subject with the usual American thoroughness. The fungus itself, and the diseased condition of peach-leaves induced by it, are fully described and illustrated, as well as the best means of counteracting its ravages, chiefly by spraying the trees. Although the book is written primarily for the benefit of peach-growers in the United States, it is well worthy of the attention of fruit-growers in other countries where peach-trees are infested by the disease.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

The Size of the Brain in the Insectivore Centetes.

I DO not think that there is any recent mammal which has so small a brain in proportion to the size of the skull as has *Centetes ecaudatus*. In an individual of this species, the property of the Hon. Walter Rothschild, which was lately living in the Zoological Society's Gardens, I found the total length of the brain to be 28 mm., of which no less than 8 mm. were taken up by the enormous olfactory bulbs. The dried skull of that individual—measured along the base and not taking into account the projecting occipital region—was 96 mm. The greatest diameter of the brain is 16 mm.; the skull in that region is from 28 to 40 mm. broad. The small size of the brain relatively to the skull has been frequently commented upon and figured in certain of the early genera of Ungulate mammals; and it may be noted that the measurements which characterise *Centetes*, undoubtedly an early type of mammal, are by no means unlike those of such a genus as *Coryphodon*, judging, that is to say, by the published figures of the brain cast and skull of that animal. The resemblance is increased by the small size of the cerebral hemispheres, and by the *complete* exposure of the corpora quadrigemina in *Centetes*. I hope shortly to give a fuller and illustrated account of the brain of this Insectivore.

FRANK E. BEDDARD.

Thermochemical Relations.

IN a letter in NATURE of February 7 (p. 348), Signor Carlo Del Lungo calls attention to certain thermochemical equalities, and asks for an expression of opinion as to whether these are the result of a casual coincidence or of a definite law. The equalities in question, if they were not accidental, would have an extremely important bearing on thermochemistry generally, but unfortunately, I believe, they are probably mere accidents of coincidence.

The two instances given would seem to indicate that when two elements combine together, the heat evolved is equal to the sum of that which is liberated when these same two elements combine separately with some third. Thus we have (modifying Signor Del Lungo's equations so as to indicate more clearly that the heat of combination refers to that of the elements taken in their ordinary molecular condition):—

$$\begin{array}{ccccc} \frac{1}{2}(2Cl_2, O_2) & + & \frac{1}{2}(2H_2, O_2) & = & (H_2, Cl_2) \\ -14\ \text{Cal.} & + & 58\ \text{Cal.} & = & 44\ \text{Cal.} \end{array}$$

and

$$\begin{array}{ccccc} (2H_2, C_{sol.}) & + & (O_2, C_{sol.}) & = & (2H_2, O_2) \\ 19\ \text{Cal.} & + & 97\ \text{Cal.} & = & 116\ \text{Cal.} \end{array}$$

I have little doubt but that such coincidences might be shown to be accidental by the existence of similar sets of compound, the heats of formation of which show no such relationship. Unfortunately, I have with me no thermochemical works to supply the requisite data. An examination of the above instances, however, will, I think, suffice to prove that the coincidences cannot be the result of any definite law.

When we expand the first of the above equations so as to represent all the stages involved, and the combinations and separations of the atoms in the various molecules, we get:—

$$\begin{aligned} &[-(Cl, Cl) - \tfrac{1}{2}(O, O) + (2Cl, O)] \\ &+ [-(H, H) - \tfrac{1}{2}(O, O) + (2H, O)] = \\ &[-(H, H) - (Cl, Cl) + 2(H, Cl)], \end{aligned}$$

which simplifies into

$$(Cl_2, O) + (2H, O) = (O, O) + 2(H, Cl).$$

This would mean that any pair of the four groups of atoms in the following diagram would combine together in any way, and yet liberate the same amount of heat—*i.e.* the thermal result would be the same whether the products were oxygen gas and hydrogen chloride, or water and hypochlorous anhydride.

$$\begin{array}{c|c} O & 2Cl \\ \hline O & 2H \end{array}$$

This, if established as a generality, would be of fundamental importance. But it is inherently improbable, and the existence of the second instance given by Signor Del Lungo seems to render it untenable. If it were true as regards the gases figuring in the above reaction, it would certainly not be true if one of the products concerned were in the solid condition; if, for instance, we dealt with solid instead of gaseous oxygen, there would be a divergence from equality equal to the heat of condensation and solidification of oxygen. Yet the second instance given by Signor del Lungo contains terms of this very character. When treated as above, assuming for the sake of simplicity that solid carbon molecules contain only two atoms, it gives

$$\begin{array}{c|c} C & 2O \\ \hline C & 4H \end{array}$$

Thus the two instances given, inasmuch as they are necessarily dissimilar, must by their coincidence show that this coincidence is the result of accident, and not of any thermochemical law.

Woolacombe, February 12. SPENCER PICKERING.

The Fraunhofer Lines in the Spectrum of the Corona.

IN some of the preliminary reports of the observations made during the last eclipse, undue importance appears to have been attached to the supposed absence of the Fraunhofer lines from the spectrum of the corona. Mr. Newall, for instance (*Roy. Soc. Proc.*, vol. lxvii. p. 365), says, "it is difficult to reconcile the marked polarisation (of the coronal light) evidenced in this investigation with the absence of Fraunhofer lines in the spectrum of the corona." Mr. Abbot, whose bolometric observations appear to him to indicate that the corona does not reflect much solar light, states that "additional evidence against the theory of reflecting particles is found in the Indian eclipse spectroscopic results of Campbell, who found a continuous spectrum from the inner corona with total absence of dark lines" (*Astrophys. Journ.*, vol. xii. p. 75).

Prof. R. W. Wood (NATURE, vol. lxiii. p. 230) has already suggested a partial reconciliation of the apparently conflicting observations, but there are other points which do not seem to have received sufficient attention.

It must be remembered that the Fraunhofer lines were observed in the corona of 1871 by Janssen, and were subsequently photographed by Schuster in 1882, and by Hills in 1893, besides having been seen by various observers on other occasions. Great weight seems to have been attached to the photographs taken in 1898 and 1900, in which no dark lines were recorded, but I venture to suggest that the apparent absence of the lines on these occasions was mainly due to the use of spectroscopes of too great a dispersion to exhibit them. While great dispersion is well adapted to render the bright line spectrum more effective, it is clearly fatal to the dark line spectrum, as in the observation of solar prominences. As a matter of fact, the recent photographs only show continuous spectrum extending to a few minutes from the sun's limb, and if one may take the evidence of the prismatic cameras, this arises mainly from the bright line giving inner corona, which probably does not shine chiefly by reflected light, and would, therefore, not necessarily show the Fraunhofer lines. This view accords well with Schuster's account of the photograph of 1882, in which it is stated that near G there was a sharp decrease in intensity at 0·29 of the solar radius from the limb, a further falling off in intensity at 0·60, with the spectrum fading out of view at 1·47; in the lower regions the spectrum was perfectly continuous, but in the upper regions the solar line G was reversed. Captain Hills also found, in 1893, the Fraunhofer lines only at a considerable distance from the limb. Stone, too, in 1874, observed the dark lines in the outer, but not in the inner corona. In these early observations and photographs we may take it that the dispersion of the spectroscopes employed was much less than in 1898 and 1900, and it would therefore seem desirable to search for the Fraunhofer lines in the next eclipse with instruments of smaller dispersion than those recently in use for the bright line spectrum and special observations.

It may be further remarked that as we do not see a section of the sun, the outer corona must be superposed upon the inner, and the fact that the Fraunhofer lines have not been observed or photographed in the inner corona, even with small dispersion, is sufficiently explained by the superposition of the dark line spectrum on the much stronger continuous spectrum of the inner corona. Such superposition would, of course, be more effective

in obliterating dark lines than bright ones. Prof. Wood's suggestion as to reducing the effective intensity of the truly continuous spectrum by passing the light through a suitably placed Nicol's prism, would accordingly be specially applicable to the inner corona.

Prof. Wood has obtained experimental evidence on a point to which attention was drawn many years ago by Ranyard (*Mem.* R.A.S., vol. xli. p. 353), namely, that if the solar light be reflected by small particles in the corona, the reflected rays will be deficient in the rays of greater wave-length. In this way the bolometric observations indicating that the corona was cooler than the bolometer are partly explained. Is it possible that the observations are to be completely explained by further supposing that the bolometer strip was outside the image of the shallow inner corona, which is probably the chief part of the corona directly emitting light and heat? The image thrown on the strip appears to have been little more than one-third of an inch in diameter, and in the account of the observations Mr. Abbot simply states that the image was brought almost tangent to the strip, so that the strip may very well have been 4 or 5 minutes from the sun's limb.

At all events, there seems to be no sufficient ground, as yet, for rejecting the view that the luminosity of the outer corona is largely due to reflected solar light, while that of the inner corona is partly due to the incandescence of solid or liquid particles and partly to gaseous radiations. A. FOWLER.

Royal College of Science, South Kensington, February 9.

Malaria and Mosquitoes.

I THINK most of those who have had much experience of the Indian jungles would be prepared to corroborate the remarks made by Mr. D. E. Hutchins in last week's NATURE (p. 371), and would perhaps be inclined to think there may be something in the opinion alluded to by him, that "Dr. Ross's splendid discovery does not quite cover the whole ground." In 1873-4 I spent some months in the notoriously malarious region at the foot of the Darjiling Himalayas, which contained some tea gardens here and there at that period, while many new ones were being opened out. The planters suffered greatly from malarial fever, and I was told by several that it was far more prevalent, and of a worse type, on gardens in process of formation, by clearing the jungle and breaking up the ground, than on either the undisturbed jungle itself or on gardens that had existed for some time. In other parts of India my camp has suffered badly from malarial fever when mosquitoes were certainly not prevalent, and when, to the best of my belief, there were none, or perhaps I should rather say, none made themselves noticeable by stinging.

On the other hand, when in Upper Assam in 1874-5, I was informed by some of the planters there, and it seemed to be a commonly received opinion, that mosquito curtains were a valuable protection from malaria. Of course at that period no explanation could be given for the supposed fact, which seemed a very mysterious one, as for the invisible 'germs,' which were thought by some to float in the air, to be excluded by curtains of ordinary mesh would be something like a man being prevented from crossing a road through inability to squeeze himself between the milestones.

18 The Common, Ealing, February 12. F. R. MALLET.

Audibility of the Sound of Firing on February 1.

THE following note was recorded here (at Littlemore, Oxford) immediately after I was called away from listening; and as it is more detailed than any I have seen, I daresay you will think it worth printing.

I held my watch in my hand and observed the sequence of the booms for some ten or twelve successive minutes. The second one showed there was regularity, and after the third the facts were clear. The sounds reached us thus:

0s. to 20s., continuous unbroken roll of guns of slightly different strength.

20s. to ± 24s., silence for 4s. or 5s.

± 24s. to ± 29s., similar roll.

± 29s. to ± 34s., silence for 3s. or 4s.

± 34s. to ± 38s., a similar roll.

± 38s. to 42s., silence to just the 42s.

42s. to 45s. exactly, a short roll culminating in three or four guns *much* louder than any of the preceding ones.

45s. to 60s. exactly, dead silence for a quarter minute.

This recurred with such perfect regularity that there was no doubt whatever about the precision of the observation.

Then I had to ride away on a bicycle about a mile, where I met another cyclist, and we stopped and listened again. The long 20s. roll was now missing, but punctual to the second or two came all the others, the last one with big guns precise.

It seems likely that the long roll was the *simultaneous* salute of the long line of ships; but I have not yet noticed any authoritative statement as to how the saluting was done. It was interesting to think that at any moment while we were listening there were no fewer than six other such salutes travelling up towards us from the Solent.

From the strength of the sounds I should quite agree with the opinion expressed in Oxford that they might well be heard another twenty miles. W. J. HERSCHEL.

February 12.

The Origin of the "Tumbling" of Pigeons.

IN reading the account of tumbler pigeons in Darwin's "Animals and Plants under Domestication," the question arose to what the habit of "tumbling" might be due.

I have since seen, in a report of an address by Prof. J. A. Thomson to the North British Branch of the Pharmaceutical Society, a statement that the peculiarities of movement of the Japanese waltzing mouse are due to the fact that only one of its semi-circular canals is developed.

It occurred to me that a similar condition might explain the movements of the tumbler. I should be much obliged if you or any of your readers could tell me where information concerning either of these examples is to be found. E. P.

February 3.

[Prof. Thomson's statement is not quite accurate. The paper to which he referred is undoubtedly that by Rawitz, in *Archiv. f. Anat. and Physiol.* (Physiol. Abth.), 1899, pp. 236–244, where it is shown that of the three canals the anterior is alone normal, and that the other two—though reduced and abnormal in their inter-relationship—are present.

The physiology of the organ has been since experimentally investigated by Alexander and Kreidl, whose paper is in Pfluger's *Archiv. f. Ges. Physiologie* (Bd. 82, pp. 541–552); and as to the pigeons, they, too, have all three canals well developed. Concerning their membranous labyrinth, some experiments of interest were made in, I think, the early nineties by Spamer and others, and an account of these and of allied investigations bearing on the question raised (by McBride) will be found in the *Journ. Anat. and Physiol.* (vol. xvii. pp. 211–217). There does not appear to be any foundation for the view to which the writer of the letter inclines.—G. B. HOWES.]

Lummer's "Photographic Optics."

THE interesting review of Prof. Silvanus Thompson's translation of Dr. Otto Lummer's "Photographic Optics," which was published in NATURE on January 3, has come under my notice. I should be obliged if you would permit me to correct a mistake which occurs both in Prof. Thompson's book and the review. Concerning the two views of Munich published in Prof. Thompson's work, which are there attributed to Dr. Miethe, you remark: "Miethe's two views of Munich from a distance of about two miles—the one taken with an ordinary lens, the other with the teleobjective—show what a powerful weapon the latter is."

Both the views in question were taken by my firm, one with an antiplanet and the other with this antiplanet in combination with a magnifying system (negative lens) as a teleobjective of our own construction and manufacture. I send you a prospectus of my firm concerning the said teleobjective and containing also the two views of Munich.

I also observe another error in Prof. Thompson's work; the lenses recently introduced by Messrs. R. and J. Beck being described on p. 80 as Messrs. Voigtländers' Collinears, instead of our orthostigmats, for which I have given them a manufacturing license, as you will see in the notice on page 1 of the prospectus I also send by book post. RUDOLF STEINHEIL.

München, February 5.

NOTHING could have been further from my intention than to do any injustice to Dr. Steinheil or his firm, and I hasten to acknowledge the justice of his criticisms upon the slips

contained in my edition of Lummer's book—slips for which I take the entire responsibility. The error on p. 100 in supposing that the Munich view was photographed by Prof. Miethe, of Berlin, arose from a confusion between two sets of telephotographic views sent me from Germany, some of which were taken by Prof. Miethe. I would point out that, in the only case in which the kind of lens used is stated, it is correctly stated to be a Steinheil's lens. I presume Dr. Steinheil is not dissatisfied with the performance of the lens in producing the picture, by whomsoever it was photographed. The other point arose from inserting at the last moment, when the sheets were going to press, a reference to Messrs. R. and J. Beck, which should have been inserted at the end of paragraph four instead of paragraph three of Chapter xi. Let me assure Dr. Steinheil that both points will be corrected in any fresh issue of the text.

February 9. SILVANUS P. THOMPSON.

The Ash Constituents of Some Lakeland Leaves.

ALTHOUGH it cannot be maintained that the amount of inorganic matter which the leaves of a tree extract from the soil on which it grows is quite independent of the chemical composition, &c., of that soil, it was deemed advisable to perform a few experiments bearing on this particular feature. Notwithstanding the considerable elevation, viz. about 400 feet, the soil in this locality is distinctly suited and adapted to the growth and healthy development of most of our well-known forest trees. It is a cold, basic clay, mostly not very stiff, on account of the presence of some gravel and peat in many places, and, generally speaking, enriched with considerable quantities of potash, silica and manganese, while a serious deficiency in lime is attested by the universal prevalence of distinctly calcifuge plants. The percentage of crude ash set down in the subjoined table was calculated from the combustion of the leaves gathered in the evening, dried first in the air and then at 100° C. The details are as described :—

Leaves of	Date	Percentage of crude ash	Percentage of lime (CaO) and of silica (SiO_2) in the crude ash
Sycamore ...	May 16	5·6	
,, ...	July 5	6	
,, ...	Aug. 13	10·5	
,, ...	Sept. 13	13	
,, ...	Oct. 11	14·2	$27SiO_2$ & 33·3 CaO.
,, (brown)	Oct. 28	15	
Wych elm ...	June 10	7·8	
,, ...	July 19	11	
,, ...	Sept. 1	13·2	
,, (yellow)	Oct. 17	18	$30SiO_2$ & 32·3 CaO.
Rowan	May 30	5·5	
,, ...	Aug. 2	6	
,, ...	Sept. 15	6·6	
,, and stalks (red)	Oct. 28	6·6	$12SiO_2$ & 35·3 CaO.
Com. beech ...	Sept. 26	5·38	$22·8SiO_2$ & 33·1 CaO.
Copper beech ...	Oct. 2	6·9	
Birch (600 ft.)...	Sept. 6	2·8	
Scots pine ...	Aug. 28	2·5	

The steady increase in the quantity of ash in the leaves of sycamore and wych elm as the season progresses is here exhibited with sufficient emphasis. The peculiarity, however, is that in the case of the sycamore the percentage does not reach the figure that it might do on other soils or under other circumstances; for instance, according to Schleiden and Schmidt, it might come up to 28 per cent.; but this proportion, I make bold to say, is never attained in any part of British Lakeland. The surprisingly large percentage of silica and lime in the ash of the deep crimson leaves and petioles of the rowan demands further investigation, inasmuch as this is a rather calcifuge tree, and the amount of silica in other allied Rosaceans is very small. According to Rismuller, the ash of dry beech leaves is 4·6 per cent. on May 7 and 11·4 per cent. on November 18; whereas Gueymard found that when gathered after natural fall and dried they yield only 5·6 per cent. ash, and my experiments do not warrant the assumption of any serious difference as respects inorganic constituents between the vernal and autumnal foliage of this tree. "Alone among the species of the first order of Mid and North Europe," says MM. Fliche and Grandeau, "the Scots pine seems to seek out siliceous soils, but the physical rather than the chemical conditions of the soil seem, as regards this species, to have a preponderant influence." Nevertheless, the percentage of ash in its first and second years' leaves is precisely the same here as it is in North Germany, and the extremely moderate inorganic pabulum that suffices to sustain it and the birch enables them to bear the privations of an upland abode. P. Q. KEEGAN.

Patterdale, Westmorland.

An Earthquake on February 10.

IN the early hours of February 10, in the town of Grazalema, there was experienced an intense earthquake, with damages to buildings, many of them being rent.

The duration was about three seconds, and the movement a compound one of oscillation and trepidation, accompanied with considerable noise.

The people ran out of the houses full of terror.

The church of Saint Joseph and some other large buildings have been very severely damaged, and also factories and mills.

The body of water that provided motive power for the machinery in one of the factories has disappeared.

Grazalema is a town of 10,000 inhabitants, situated in a hilly district of the province of Cadiz, at about 70 kilometres, nearly due north, from Gibraltar. AUGUSTO ARCIMIS.

Instituto Central Meteorologico, Madrid, February 13.

The late Prof. Hermite.

YOUR interesting memoir of Prof. Hermite differs in one detail from the account in "Men and Women of the Time." It is said there that he was born at Dieuze, in Lorraine, and that he was for a while at Nancy before going to Paris.

W. B. C.

THE RADIO-ACTIVITY OF MATTER.

AT the commencement of the year 1896, in carrying out some experiments with the salts of uranium, the exceptional optical properties of which I had been studying for some time, I observed that these salts emitted an invisible radiation, which traversed metals and bodies opaque to light as well as glass and other transparent substances. This radiation impressed a photographic plate and discharged from a distance electrified bodies—properties giving two methods for studying the new rays.

The phenomenon does not appear to be influenced by any known external cause, such as a variation of temperature or a luminous excitation; it is entirely different from phosphorescence; is not weakened in an appreciable manner by time, even at the end of several years; and is emitted spontaneously without any apparent exciting cause. The radiating property appeared, firstly, to be bound up with the presence of the chemical element uranium; the metal discharges electrified bodies three to four times faster than its salts.

If some fragments of uranium or of one of its salts are placed upon a photographic plate wrapped in black paper or covered by an aluminium leaf, and if between the uranium and the plate various substances are interposed, there is obtained at the end of several hours or days, radiographs showing that the radiation is propagated in straight lines, and traverses different bodies unequally. In the radiographs the edges of the plates of glass, or of thin plates of other substances, throw a sort of shadow, which is still unexplained. This phenomenon, as well as an inequality obtained twice accidentally through parallel and crossed tourmalines, led to the belief at the commencement of these researches that these rays had properties in common with light. But all the later experiments have shown that the new radiation undergoes neither reflection, refraction nor polarisation.

The uranium radiation dissipates with equal rapidity either positive or negative electric charges; the effect is unequally transmitted through screens of different materials according to their nature and according to the order in which they have been simultaneously interposed. This fact leads to the prediction of the heterogeneity of the radiation. The dissipation of the charges of an electrified body submitted to the uranium radiation takes place through the action of the surrounding gas, which is thereby made conducting; the air keeps this property during some instants, and if, after having been influenced, it is blown on to an electrified body, the latter is discharged. A sphere of uranium remains charged if it is placed in a vacuum; in air it puts itself in equilibrium as regards potential with the surrounding space. The rate of leak increases with the potential, and, for high potentials, tends to a constant.

If two conductors are arranged at some centimetres apart, one of which is connected with a source of electricity, and if a piece of uranium is brought near, there is established between the two conductors a continuous current of electricity. Such are the principal facts that I had observed.

In 1897 Lord Kelvin and Messrs. Beattie and S. de Smolan varied the conditions of the preceding experiments, and showed that the uranium radiation established between two metals in air the same equilibrium as a drop of water which united them. In 1899 Mr. E. Rutherford made it clearly apparent that the conductibility set up in gases by uranium was due to a phenomenon of ionisation identical with that which, according to the experiments of Prof. J. J. Thomson, is provoked by the Röntgen rays.

In 1898 the discovery of new radiating bodies gave a new and fruitful impulse to these studies. Mme. S. Curie and M. Schmidt had recognised that thorium possesses analogous properties to those of uranium; then Mme. Curie observed that certain uranium minerals were more active than either metallic uranium or thorium. M. and Mme. Curie concluded from this that there existed other radio-active bodies, and undertook to isolate them.

I cannot analyse here the chemical part of the fine work of M. and Mme. Curie, who, working with the electrometer as the chemist works with the spectroscope, succeeded in extracting from pitch-blende two very active substances: on the one hand, a product containing bismuth and a body which they called polonium; and, on the other hand, a mixture of barium and another new substance, radium.

When they had prepared some centigrams of products the activity of which, progressively increasing, became several thousand times greater than that of uranium, M. and Mme. Curie were good enough to give me some milligrams, so that we could thus pursue parallel researches on the new properties.

M. and Mme. Curie recognised, among other important properties, that these bodies excite the fluorescence of the platinocyanides; that the salts of radium are spontaneously luminous; and further, that all bodies receiving the new radiation become radio-active in their turn, but that they gradually lose this property with time. They observed also, as well as Giesel, who prepared mixtures analogous, but less active, to those of M. and Mme. Curie, that the salts of radium increase spontaneously in activity for some time after their preparation, whilst the activity of polonium salts diminishes. The new radiation produces various chemical actions, alteration of the platinocyanides, violet coloration of glass, production of ozone, &c.

For my part, I have observed that the polonium radiation does not traverse even black paper; it is much less penetrating than that of radium, which, moreover, provokes in bodies which it encounters a secondary penetrating radiation which marks a photographic plate in the immediate neighbourhood of the points struck. I have been able to establish also that the intensity of the phosphorescence excited by radium varies as the inverse square of the distance of the excited body from the radiating source; that the unequal weakening produced by a given screen on the phosphorescence of different substances furnishes a new proof of the heterogeneity of the exciting radiation; and, lastly, that the radiation of radium restores the property of becoming phosphorescent by heat to such bodies as fluor spar, leucophane, &c., which had lost this property by a preliminary heating.

I would here point out the very interesting researches of M. and Mme. Curie, M. Owens, and of Mr. E. Rutherford upon the penetrating rays of thorium. Mr. E. Rutherford has found that thorium compounds emit, in addition to this ordinary radiation, a very penetrating "emanation" that produces temporary radio-activity in substances in the neighbourhood, if the bodies are all uncharged. With charged conductors the radio-activity is produced on the negatively charged body. The radio-activity can thus be concentrated on the surface, of thin wires, and removed by hydrochloric and sulphuric acids, whose solution, when evaporated, leaves the active portion behind. Thorium may perhaps owe a part of its properties to a new element, actinium, discovered in 1900 by M. Debierne, and which is as active as radium.

At the end of 1899 several observers discovered, nearly simultaneously, that the rays from certain radiating substances were deviated by a magnetic field. This was first shown by M. Giesel with preparations of polonium and radium, then by MM. S. Meyer and E. v. Schweidler, who some days later showed the same thing with preparations made by M. Giesel, and then, a little later, without having any knowledge of these observations, I recognised that the radium radiation concentrated itself upon the poles of a non-uniform magnetic field, whilst the radiation of polonium prepared by M. and Mme. Curie is not deviated. The preparation of polonium of M. Giesel was, then, not the same substance as that of M. and Mme. Curie.

It resulted from these observations that there exists two kinds of radiations, one not capable of deviation and of which the nature is still unknown, the other capable of deviation, which later experiments have identified with the kathode rays. Somewhat later, M. and Mme. Curie recognised that both these rays coexisted in the radium radiation. The non-deviable rays are much less penetrating than the deviable rays; the polonium radiation is limited in air to a kind of sheath of some centimetres in thickness. I might add that recently M. Villard has proved the existence in the radium radiation of very penetrating rays which are not capable of deviation. M. Debierne has recognised that actinium emits some deviable rays.

I have devoted numerous experiments to the study of the deviation of radium in the magnetic field. This radiation is dispersed by the field into rays of different natures, like as light is dispersed by a prism. For each simple radiation, the trajectory in a plane perpendicular to a uniform field is a circumference of radius R, which brings back the radiation to the point of departure. If the radiation makes at the origin an angle α with the axis of the field, the trajectory is a helix rolled on a cylinder parallel to the field and of radius R sin α. The product $H\rho$ of the component of the field normal to the displacement at a point, by the radius of curvature of the trajectory in this point is constant, and may serve to characterise each simple radiation.

To obtain a beam in which each simple radiation would have a unique trajectory, a radiant source may be taken of very small diameter, the radiation being received after traversing a narrow gap in a sheet of lead.

It is shown by experiment that it is sufficient to arrange between the polar pieces of an electromagnet a horizontal photographic plate upon which is placed, in the centre of a little leaden dish, the radiating source of very small diameter. The rays emanating normally to the plate and brought back orthogonally on it are the most efficacious; the impression, large and diffuse, is thrown on one side of the field, and constitutes a sort of spectrum which is sufficiently pure. If one works in the dark, and places on the photographic plate bands of various substances, aluminium leaf, copper and platinum foil, &c., it is seen that under the screens the impression of the deviated rays is limited by elliptic arcs, distinguished from each other. Each screen arrests different radiations, the most deviated being the most absorbable. The dimensions of the elliptic arcs are in accordance with theory. The absorption is the same in air and in an absolute vacuum. These experiments constitute a sort of magnetic spectrum analysis of the deviable radiation.

The identification of this radiation with the kathode rays requires two other verifications—the demonstration of the existence of a transport of electric charges and that of a deviation in an electrostatic field. M. and Mme. Curie have made the first verification, and I have realised the second. M. and Mme. Curie placed a screen, isolated from all contact with the air, in connection with an electrometer, and observed that the radium radiation charged this screen negatively, whilst the source itself, if it is properly isolated, is charged positively. The current for each square centimeter of radiating surface was about 4.10^{-13} electromagnetic C.G.S. units.

For my part, I showed that in an electric field the radiation of radium undergoes a parabolic inflection in the contrary sense to the field, as would be the case with a flux of negatively charged particles. The comparison of the electrostatic and magnetic deviations allows of the determination, like that of Prof. J. J. Thomson for the kathode rays, of the velocity of the particles. For the particular radiations defined by $H\rho = 1600$, the velocity has been found equal to 1.6×10^{10}—about one-half of that of light. The ratio of the material masses carried off to the charges which they transport has been found equal to 10^{-7}, a number identical with that corresponding to the kathode rays. From these numbers, and that which results from the experiment of M. and Mme. Curie, it follows that for each square centimetre of surface of the radiating substance studied there escapes a flux of material which would amount to a loss of about one milligramme in one thousand million years. If the material emission, which appears to be of the same order as the evaporation of certain scented substances, is the first cause of the observed phenomena, there would be no contradiction between the apparent absence of any source of energy and the continuous emission of this energy.

The most deviable portions of the radium radiation pass easily through all bodies when they are very near the source, but are stopped when these bodies are some centimetres distant. I have further recognised that, after having traversed a screen, the radiation possesses the same magnetic deviability.

I can only give here the physical properties of radio-activity. One of the most important applications has been the discovery, by M. and Mme. Curie, of new chemical elements. Radium has a high atomic weight, and a characteristic spectrum observed by M. Demarçay. Polonium, according to recent researches, has a spectrum in the ultra-violet. These bodies possess, then, the characters of simple substances.

Recent studies on induced radio-activity appear to open still new horizons. It has been mentioned already that a body becomes temporarily active when it receives the radiation of an active body. M. and Mme. Curie and M. Giesel have recognised that the induced activity thus provoked was much greater if the body was mixed in solution with an active salt and then afterwards separated by precipitation. In thus rendering barium active with actinium, M. Debierne has recognised that the active barium behaves as a different body from ordinary barium, that it could be separated chemically and concentrated. Active barium thus resembles radium. It differs from it by the absence of a peculiar emission spectrum and by the fact that its activity weakens with time. I would add that recently Sir W. Crookes, who has made numerous experiments by the photographic method, announced that he had prepared uranium that was almost inactive. According to these experiments, as well as those of M. Debierne, M. Giesel and myself, it would appear to follow that the activity of uranium is due in great part, if not altogether, to a small quantity of actinium or of another radio-active body.

These facts, although increasing the complexity of radio-activity from the chemical point of view, do not, however, remove from it its value; it can be remarked that if the existence of uranium as a simple body had been unknown up to the present, its radiant properties would have permitted of its isolation, even though they are not inseparable from its existence.

This short account shows that a new order of phenomena has arisen from the study of a new property of matter—radio-activity. HENRI BECQUEREL.

PROGRESS OF THE MAGNETIC SURVEY OF THE UNITED STATES.

THE special division of the United States Coast and Geodetic Survey devoted to the magnetic survey of the United States, and countries under its jurisdiction, was created by the late superintendent, Dr. H. S. Pritchett, now president of the Massachusetts Institute of Technology, on July 1, 1899; and Dr. L. A. Bauer was put in charge of the division. Since that date magnetic observations—namely, declination, dip and intensity of magnetic force, have been made up to December 31, 1900, at about 500 stations distributed over the United States, Alaska and the Hawaiian Islands. At most of the stations permanent marks have been established for the use of the surveyor. Special consideration has also been given to the needs of the mariner, especially in Alaskan waters, where occur places of pronounced local attraction affecting the compasses on board ship all the way from ¼ of a point to 4 points.

Special stations, known as "repeat" or "secular variation" stations, have also been established in different parts of the United States. At these, observations will be repeated at stated intervals in order to determine the amount of secular change in the magnetic elements. It is the endeavour, whenever possible, to establish such stations in the vicinities of colleges and universities, as experience has shown that on college grounds there is hope for a permanency of station for a fairly long interval.

Of special State surveys mention may be made first of the completion of the magnetic survey of Maryland, which was undertaken primarily by the Maryland Geological Survey and assistance rendered by this Bureau; second, the completion of the magnetic survey of North Carolina, conducted under the joint auspices of this Bureau and the North Carolina Geological Survey; third, the completion of the magnetic survey of West Virginia; and fourth, the completion of the magnetic survey of Iowa.

Fair progress has also been made in the establishment of the magnetic base stations, where the countless variations of the earth's magnetism will be recorded photographically. Thus, a temporary magnetic observatory

has been in operation at Baldwin, Kansas, since July 1, 1900, and the buildings for the primary or principal magnetic base station, situated at Cheltenham, Md., sixteen miles south-east of Washington, have been completed and the installation of the instruments is now taking place. Special declination readings from 7 a.m. to 4 p.m. have been made at Gaithersburg, Md., since March 22, 1900, and at Sitka, Alaska, since October 1, 1900. The sites for the magnetic base stations at Sitka, Alaska, and near Honolulu, Hawaiian Islands, have been determined and preparations made for the erection of the buildings. It will be the endeavour to have these magnetic observatories completed in time for co-operation with the proposed Antarctic expeditions.

Furthermore, special simultaneous observations have also been made on special days at various times, the purpose of these special observations being to determine over how large an area the variations, as recorded at the base stations, may be regarded as applying.

Again, various special investigations both of an experimental and a theoretical character have been undertaken, and considerable attention has been paid to the thorough training of observers and to the proper correlation of the various magnetic instruments. During the autumn of 1899 a set of coast survey magnetic instruments was compared with the standard instruments at the following foreign observatories: Kew, England; Potsdam, Germany; Pavlovsk, Russia; and Parc St. Maur, France.

The following publications have been issued, namely: Appendix 9, giving a general report of the magnetic survey of North Carolina; and Appendix 10, on the magnetic work of the U.S. Coast and Geodetic Survey, both appendices appearing in the Report of the Survey for 1898-99. Good progress has also been made with the new edition of the Coast Survey's magnetic declination tables and isogonic charts for the United States and Alaska for 1900.

MAX JOSEF VON PETTENKOFER.

IT is with great regret that we record the death, in very sad circumstances, of the veteran German hygienist, Prof. Max von Pettenkofer. He was born in 1818, and was, therefore, in his eighty-third year at the time of his death.

Pettenkofer's name was known throughout the civilised world as that of the great professor of hygiene at Munich, and he made the Munich school famous. Among medical and hygienic circles in Europe he was personally well known and respected for his fearless defence of what he believed to be true and for the breadth of his views. Sometimes during a discussion on some subject on which he felt strongly, the burly form of the great German hygienist would arise, and with a few vigorous sentences he would scatter the arguments of his opponents like chaff before the wind. A notable instance of this occurred at the meeting of the International Congress of Hygiene and Demography at Vienna in 1887 during the discussion on quarantine; the supporters of that antiquated method of prevention had most of them aired their views, when Pettenkofer got up and brusquely told them that it was a question of cleanliness, that England had spent many millions in improving the sanitary condition of her towns and had now no fear of cholera, and that what other countries should do was to follow England's example, and then they would have no need for the vexatious and, for the most part, useless restrictions of quarantine.

Pettenkofer published a great many valuable papers on public health subjects; the list of their titles fills nearly a page and a half of the great "Index Catalogue of the Library of the Surgeon-General's Office, United States Army"; and even that is not complete, as it does not include his remarkable paper on "Die Immunität von Lyon gegen Cholera." But he was too busy with teaching the many pupils who flocked to him from all parts of the world, and with investigating, to write large treatises, two on cholera being the longest productions of his pen; this, indeed, was his favourite subject, and his books and papers on it number about a score, the best known of them probably being the one entitled "Boden und Grundwasser in ihren Beziehungen zu Cholera und Typhus," in which he propounds his well-known theory that the spread of cholera and enteric fever depends upon the movements of the subsoil water, their prevalence increasing after a fall in the level of that water. This view he stoutly maintained, undaunted even by the fact that the City of Lyons (the invariable immunity of which from epidemics of cholera, in spite of several introductions of the disease, he considered quite explicable on his theory) was very subject to enteric fever, from which it ought, on the same theory, to be immune.

Whether, however, we regard his ground-water theory as correct or not, we cannot but admire the practical results of the measures taken under his advice to purify the subsoil of Munich, which, from being a hotbed of enteric fever, has become remarkably free from that disease.

He also wrote on sewerage arrangements, on the hygiene of ships, and on "the relations of the air to clothing, dwelling and soil," the last being a course of popular lectures; and he was co-editor of the *Zeitschrift für Biologie* (München) from 1865 to 1882.

Pettenkofer was much interested in chemical work connected with hygiene, and devised the method (ever since known by his name) of determining the percentage of carbonic acid in air, which has been adopted by all observers until quite recently.

Personally he was gentle and amiable, as a little incident will suffice to show. In 1894 the present writer, not finding him at the International Congress of Hygiene at Budapest, went to see him at his home at Seeshaupt, on the Starnberger See, near Munich; he was crossing on one of the steamers, and, when about half way towards the farther end of the lake, was surprised to meet Pettenkofer on board. The latter had gone some distance round the lake by rail and got on the steamer at one of the stopping places, so as to come part of the way to meet his guest for the day and escort him to his house.

Not having received the usual New Year's greetings from him on a card bearing a photograph of one of the fountains of the "Pettenkofer water supply" at Munich, with a small profile medallion of the professor above it, the writer feared that he was not well, but was little prepared for the terrible news which so soon followed.

It was no doubt his retirement, even at that lovely spot, and his forced inactivity, that preyed upon poor Pettenkofer's mind, and not even the patent of hereditary nobility granted him by the Emperor seems to have solaced him, for we have just received the melancholy and pathetic news that this grand old man, tortured by an incurable disease and wearied by his inability to work any more for the benefit of his fellow-men, has put an end to his sufferings by a pistol shot. W. H. C.

THE ROYAL INDIAN ENGINEERING COLLEGE, COOPERS HILL.

LAST week we printed a report, taken from the daily papers, of the deputation to the Secretary of State for India asking for an inquiry into the working of the Royal Indian Engineering College. Lord Kelvin, who headed the deputation, expressed disappointment at the nature of Lord George Hamilton's reply, and if, in criticising that reply, we should fall into error in consequence of the inconsistencies in the reports of the

interview, we must apologise to Lord George Hamilton beforehand if we should unintentionally misrepresent him.

The Secretary of State is of opinion that some of those who signed the memorial have been misled by *ex parte* statements; but the memorial was founded solely on the letters of dismissal and the memorial to the Secretary of State sent by the dismissed members of the staff. Lord George Hamilton seems to forget that Colonel Ottley's report is quite *ex parte*, for the staff have not only not had an opportunity of answering it, but they did not know of its existence until the reply of the Secretary of State was given.

We are assured that none of the letters to the daily papers were written by members of the staff, and the letters from the students were unanimously condemned by them.

Lord George Hamilton stated that Mr. (now Sir Henry) Fowler's committee of 1895, the composition of which it would be interesting to know, was of opinion that the number of the staff was out of all proportion to the number of the students, but we are very much mistaken if comparison with other institutions would not show that the number of the staff is by no means excessive. The numbers of the staff must depend more upon the variety of the subjects taught than upon the numbers of the students. In an engineering college especially, if it be worthy of the name, the variety must be considerable. The percentage of staff to students will decrease with the number of students; at Coopers Hill numbers of students are denied admission each year.

Until Colonel Ottley's report is published in full, it will be impossible to judge of the statement that it shows "a very unsatisfactory state of affairs at the College." That this is so is all the more surprising as the College is now self-supporting. More than this, year after year the Secretaries of State have spoken of the satisfactory state of the College when addressing the students on the prize days, and this after receiving the reports of the presidents.

The state of affairs is certainly unsatisfactory from one point of view. A college can no more get on without college meetings of the teaching staff than a Government can get on without Cabinet meetings of those in charge of different departments. Lord George Hamilton's reply indicates pretty clearly that while the teaching staff is never consulted, it is not quite certain whether the governing body is the Board of Visitors or the president of the College, who has made it quite clear that he knows nothing of educational methods.

It is impossible not to come to the conclusion that the main obstacle to improvement in the work at Coopers Hill has been the unsatisfactory position of the staff; they are entirely under the hands or the heel of the president, who may have had no experience whatever in matters of education. The staff are unable to forward recommendations to the India Office except through the president, and however much they may be desirous of improving the teaching, they are powerless.

There seems to be some misunderstanding about the teaching of electrical engineering. Some years ago several members of the staff urged the then president to introduce electrical engineering as a compulsory subject; the president would not further the proposal. It was next suggested that the subject should be made alternative with some of the other third-year work; this was accepted, and since that time many students have worked at this subject for about fourteen weeks in their third year. Two of the members of the staff who are dismissed were instrumental in obtaining this concession from the president and the India Office. It is difficult to reconcile the desire to have electrical engineering as a compulsory subject with the statement in the *Times* that, "with respect to electricity, the India Office had taken the opinion of Sir William Preece, and came to the conclusion that a demonstrator was capable of giving all the necessary instruction," unless it means that electrical engineering is to be taught as an art and not as a science, which will probably result in the students having an insufficient theoretical knowledge of the science they have to apply, and will certainly lead them into difficulties on an emergency.

The reference to Dr. Brightmore would lead a reader of the speech of Lord George Hamilton, as it appears in the papers, to think that he had been appointed recently to take the head of the engineering branch. Some of our readers will doubtless remember that Dr. Brightmore was appointed in September 1899 against the wishes of the late president, Colonel Pennycuick, and that his appointment was the principal cause of the resignation of that officer.

The statement that "the upshot of the whole matter would be this: there would be an increase in the hours of work in class and lecture from twenty-six to thirty-two" hours per week, is extremely misleading. A reference to the College time-tables would show that before the advent of Colonel Ottley the time of study for first year students was thirty-three hours a week, and for second year students thirty-four. At that time the third year students had in lecture only 14 hours 20 minutes; but no account is taken of the project, the engineering and turbine designs, or the architectural design, which latter was alternative with work in the chemical or physical laboratory, and the hours for which do not appear in the time-table. If the numbers of hours actually spent in lecture by students of the three years are added together and divided by three, a number not far from twenty-six is obtained, but it is very disingenuous to insinuate that in the time of previous presidents the students did only twenty-six hours' work a week.

Another effect of the new scheme is said to be the raising of the standard of the entrance examinations. When the College was first opened the entrance examination was conducted by the Civil Service Commissioners; later, when it was opened to all students who desired to present themselves in order to compete for the Indian appointments in the College itself, the examinations were carried on at the College by some members of the staff, and the number of the candidates was often less than the vacancies. As the order has always been given to the presidents to make the College "pay," there was a tendency to admit as many as possible, so as to fill the building. Of late years the number of candidates has exceeded the vacancies, and the examination has been selective, to the great satisfaction of the staff, who thus have better material with which to work. This stiffening of the examinations has been going on for some time, and is quite independent of the recent dismissals or of Colonel Ottley's report.

Another very misleading statement is that 39 per cent. of the students fail; this is made so as to infer that the teaching is inefficient. This number has probably been arrived at by counting the number of students who enter in one year, and the number of the same batch who obtain diplomas at the end of the third year; but no account appears to have been taken of the fact that many students withdraw of their own accord before completing their college course.

The statement that outside examiners would be appointed might induce a casual reader to suppose that the examinations are carried out by the teachers themselves, as, indeed, the *Times* categorically states, "the teachers were also examiners with no one from the outside." This is erroneous; outside examiners have always been the rule; a large proportion of the marks are given by outsiders, and in some subjects as much as half of the marks are so awarded. The outside examiners are absolutely independent; their papers are not seen by the lecturers.

Extracts of the reports of these examiners are read by the president on the prize day.

What we have stated above quite supports Lord Kelvin's expression of disappointment at the reply vouchsafed to the deputation.

It appears also, from Lord George Hamilton's reply, that he does not consider the men of science employed at Coopers Hill to be servants of the Crown, and that consequently a different measure is to be meted out to them than that proper to the unscientific clerks in a department of the India Office. He is reported to have said that the age limit of the professors at the College is sixty; surely, under the Superannuation Act of 1859, it is sixty-five, and the professor may continue in office until seventy if the president certifies that the work is being efficiently performed.

Under the same Act, if it were desired to reorganise the College, there was a regulated way open which, beyond all question, would be the one employed in any reorganisation of the India Office itself; and surely under these circumstances it was the duty of the representatives of science to ask for simple justice. Chap. VII. of the Superannuation Act runs as follows:—

"It shall be lawful for the Commissioners of the Treasury to grant to any person retiring or removed from the public service in consequence of the abolition of his office, or for the purpose of facilitating improvements in the organisation of the department to which he belongs, by which greater efficiency and economy can be effected, such special annual allowance by way of compensation as on a full consideration of the circumstances of the case may seem to the said Commissioners to be a reasonable and just compensation for the loss of office; and if the compensation shall exceed the amount to which such person would have been entitled under the scale of superannuation provided by this Act *if ten years were added to the number of years which he may have actually served*, such allowance shall be granted by special minute, stating the special grounds for granting such allowance, which minute shall be laid before Parliament, and no such allowance shall exceed two-thirds of the salary and emoluments of the office."

Another point that the noble lord appears to have omitted to answer is Prof. Johnstone-Stoney's contention that the dismissals were not even in accordance with the terms of appointment.

If the above assertions are true, and we have every reason to believe that they are, is it surprising that the dismissed members of the staff should ask for further inquiry? And it is only natural that others, as represented by the signatories of the memorial presented on Tuesday week, should wish to support their application. It would appear that the inquiry is even more urgently needed since we have heard Lord George Hamilton's reply.

But the condition of the staff at Coopers Hill is only a small part of a large question, and the memorialists are quite justified in saying that "such dismissals are likely to affect adversely the cause of scientific teaching in the United Kingdom." An action of this kind by a Government department will not tend to raise the dignity of scientific teaching in the eyes of the general public, and unless England is to fall far behind other countries it is essential that due regard be paid to those fundamental subjects of science on which the welfare of the whole community depends.

All interested in English education, and we may add that their number now includes the more intelligent of our manufacturers, know full well that the rapid strides now being made by American and German engineers are due to a gradual perfecting of the welding of science to practice. In America, a four years' course, including both the science and art of engineering, is the rule in the engineering colleges. The engineering department of the University of Birmingham starts with a four years' course in which those subjects which have been summarily and, as we hold, unwisely, ejected from the Coopers Hill curriculum will hold a large place.

Lord George Hamilton now knows what the representatives of English science think of the proposals for which he is responsible. The opinion of the professional electrical engineers of this country will be gathered from the following comments upon the case, which appeared in last week's *Electrician*:—"The crucial question, therefore, is whether the proposed changes will enable the College to turn out better engineers. What, then, are these changes? They involve the abolition of the chairs of physics, chemistry, hydraulic engineering and mechanism, the assistant professorship of engineering, the lectureship in accounts, the demonstratorships in the mechanical laboratory and in physics, and the instructorship in electrical engineering. The selection is amazing! What sort of engineering college training can it be that can dispense with a teacher for any one of these subjects? And, considering that the supply of telegraph engineers has been one of the chief features of the College, how are we to regard patiently the abolition of the professorship of physics and the instructorship in electrical engineering? This is economy false to the core—so palpably absurd, indeed, that we doubt if economy is the real reason for these startling changes. Lord George Hamilton stated that in the revised curriculum 'electricity would be thoroughly taught,' as Sir William Preece had advised them that 'a demonstrator was capable of giving all the necessary instruction.' We entirely dissent from this view; with the rapid increase in the engineering applications of electricity, not less but *far more* instruction in electrical and allied subjects becomes increasingly necessary in any engineering college."

Of one thing we may rest assured. When the Indian engineers only know chemistry "to the extent required to enable the engineer to interpret results given by professional chemists," as quoted from the official documents by Lord Kelvin; and physics and electrical science as imparted by Sir William Preece's "demonstrator"; the reputation of a noble service, which has during the last quarter of a century achieved such admirable results, will soon be a thing of the past.

NOTES.

WE have received the following circular relative to the dismissals at Coopers Hill College. "In consequence of the unsatisfactory nature of Lord George Hamilton's reply to the deputation which waited upon him on Tuesday, February 12, to present the memorial relating to the dismissals at Coopers Hill, it has become necessary to take action in Parliament. It would be of great service if the signatories to the memorial would draw the attention of their local Member of Parliament to the action of the Secretary of State for India, and ask him to interest himself in the matter when it comes before the House. A copy of the memorial will be forwarded to any signatory on application to The Secretary, The Museums, Cambridge."

AN abstract of an interim report on yellow fever, by Dr. Durham and the late Dr. Myers, has been received by the Liverpool School of Tropical Medicine. The abstract mentions that a small bacillus has been found in the internal organs of those dead of yellow fever. From the fact that this bacillus has been found constantly and in apparently "pure cultures," it is concluded that there is good reason to suppose it to be the cause of the disease, but at the same time the need of more experimental work to establish the claim is recognised. Careful search was made for parasites of the nature of protozoa, but the observers conclude that yellow fever is not caused by that class of parasite.

In connection with the subject of the foregoing note, it is of melancholy interest to refer to articles in the *Jornal do Commercio* of Para, on the subject of the death of Dr. W. Myers and of the illness of his colleague, Dr. H. Durham, who both contracted yellow fever in the pursuit of their dangerous duties whilst acting on the Yellow Fever Expedition of the Liverpool School of Tropical Medicine. The following is a translation of parts of the articles :—"January 18. Drs. Durham and Myers.—Lying at present in the hospital Domingos Freire are the illustrious English doctors who came here in commission on behalf of the Liverpool School of Tropical Medicine to study yellow fever. Daily exposed to infection from the terrible disease, the day before yesterday, after an autopsy at an early hour on a case of very acute form of yellow fever, they began to feel the first symptoms, and without loss of time entered the hospital. A clinical service was arranged, assisted by numerous colleagues of the illustrious men of science, under the direction of their medical assistant. We sincerely hope for the recovery of the distinguished doctors, who through their noble dedication to science have been rendering us such great services, their investigations having already achieved entirely new results from which we may be permitted to look for promising advantages for our country and for humanity at large." "January 22.—In the isolation hospital Domingos Freire succumbed most rapidly and unexpectedly the English bacteriologist Dr. W. Myers, who came to this capital solely for the study of the disease to which he has fallen a victim—yellow fever. Following on a prolonged autopsy, both Dr. Myers and his illustrious companion, Dr. Durham, fell ill themselves, the latter still being under the burden of the disease. Dr. Myers' death took place on the afternoon of the 20th, and the burial was carried out yesterday morning, the coffin being carried from the hospital to the cemetery of Tanta Isabel by Dr. Paes de Carvalho, Governor of the State of Para, and Drs. Francisco Miranda, Americo Campos, Pontes de Carvalho, Gonçalo Lagos and other gentlemen alternately. At the side of the grave the following doctors spoke :—Paes de Carvalho, who showed by the sadness of his expressions the deep grief which he felt, and Americo Campos, as representative of the Medico-Pharmaceutical Society of Para. There were present a large number of members of the English colony, all in deep mourning and visibly affected."

The neglect of ethnography in Great Britain has often been pointed out in these columns. In his presidential address to the Anthropological Institute on February 4, Mr. C. H. Read showed that not only is our country far behind other nations in respect to provision for teaching the subject, but also in ethnographical collections and accommodation for them. Germany, with colonial possessions infinitesimal in extent compared with those of England, has completely distanced us in this respect; the British Museum collections from British possessions being inferior to those of the Berlin Museum, which has exhibits seven times as numerous as those in the British Museum, and this disproportion is rapidly increasing. After the Benin expedition we allowed ourselves to be outbid in the purchase of specimens, and Mr. Read said that attention has in Germany been officially called to the fact that England seems to be too poor to be able to compete effectively for objects that are indispensable for her ethnographical collections. Most people will agree with Mr. Read that this state of things is a national disgrace, and shows a neglect of scientific interests as astounding to thoughtful minds as it is deplorable. In the matter of ethnographical material, we are apparently becoming renowned as the nation of lost opportunities. Can nothing be done to stimulate national interest in the collection of objects and conservation of knowledge fast disappearing before the advance of civilisation?

Mr. Vaughan Cornish, whose name is closely associated with the wave-like forms assumed by drifted materials, is now engaged on the Canadian prairies photographing and studying the forms assumed by drifting snow. Thanks to the liberality of the Canadian Pacific Railway Company and the interest evinced in the investigation by Sir William van Horne, Mr. Cornish writes that his work proceeds satisfactorily, and enough has already been done to justify the expedition.

The last mail from Japan brings news that Mr. A. Imamura has been nominated assistant professor of seismology at the Imperial University of Tokyo, where he will work with Dr. F. Ōmori at the Seismological Institute. In addition to this Institute, there is in Tokyo a Seismological Investigation Committee, which has already published thirty-two volumes relating to its work, and also, at the Central Meteorological Observatory, a department which receives and analyses the registers relating to earthquakes observed at about one thousand co-operating stations distributed throughout the Empire.

The next congress of the South-eastern Union of Scientific Societies will be held at Haslemere on June 6–8, under the presidency of Mr. G. A. Boulenger, F.R.S.

The inaugural meeting of the Birmingham local section of the Institution of Electrical Engineers, which was to have been held on January 23, has now been fixed for Wednesday, February 27, in the University Buildings. Dr. Oliver Lodge, chairman of the section, will deliver an inaugural address, and the president of the Institution, Prof. J. Perry, F.R.S., will be present.

It is announced in the *British Medical Journal* that an Italian Society of Biology has recently been founded on the initiative of many distinguished naturalists. The first meeting of the society will probably be held in Rome during the coming Eastertide. The object of the society is to promote the study of the biological sciences and everything relating to the advancement and teaching of these. The society will publish a bulletin giving an account of its proceedings.

On Saturday next, February 23, Lord Rayleigh will deliver the first of a course of six lectures at the Royal Institution on sound and vibrations. On Tuesday, February 26, Dr. Allan Macfadyen will begin a course of five lectures on the cell as the unit of life, and on Thursday, February 28, Prof. Percy Gardner will deliver the first of a course of three lectures on Greek and Roman portrait sculpture. The Friday evening discourse on February 22 will be delivered by Sir William Roberts-Austen, K.C.B. His subject will be "Metals as Fuel."

The Paris correspondent of the *Chemist and Druggist* states that M. Berthelot, one of the permanent secretaries of the Paris Academy of Sciences, is taking steps to carry out a resolution of that body to distribute annually a gold medal in memory of Lavoisier. M. Paulin Tasset, the engraver, is preparing the die of the medal, and has taken as a model a medallion of the great chemist in profile by David d'Angers. The inscription will be of the simplest nature. The name "Laurent Lavoisier" will appear under the profile, and on the back of the medal the words "Institut de France, Académie des Sciences, Medaille Lavoisier." The medal is likely to become greatly prized by chemists, and will be given for distinguished chemical research. It will be awarded for the first time this year by the Academy of Sciences, and its annual distribution is assured by a balance remaining over from the subscription for the monument, which was unveiled last summer behind the Madeleine Church, Paris.

The anniversary meeting of the Geological Society was held on Friday, February 15. The officers were appointed as follows :—President: Mr. J. J. H. Teall, F.R.S. Vice-presi-

dents: Mr. J. E. Marr, F.R.S., Mr. H. W. Monckton, Prof. H. G. Seeley, F.R.S. and Mr. W. Whitaker, F.R.S. Secretaries: Mr. R. S. Herries and Prof. W. W. Watts. Foreign Secretary: Sir John Evans, K.C.B., and Treasurer: Dr. W. T. Blanford, F.R.S. The following awards of medals and funds were made:—The Wollaston Medal to Dr. Charles Barrois, of Lille, the Murchison Medal to Mr. A. J. Jukes-Browne, of Torquay, the Lyell Medal to Dr. R. H. Traquair, of Edinburgh, and the Bigsby Medal to Mr. G. W. Lamplugh, of the Geological Survey. The Wollaston Fund to Mr. A. W. Rowe, the Murchison Fund to Mr. T. S. Hall, of Melbourne, and the Lyell Fund to Dr. J. W. Evans and Mr. A. McHenry. The president delivered his anniversary address, which dealt chiefly with the evolution of ideas during the nineteenth century as to the genesis and classification of igneous rocks.

DURING the last fortnight an interesting series of letters on the audibility of the minute-guns at Spithead has appeared in the *Standard*, and several correspondents refer to other instances of the reports of guns being heard at great distances. The firing at Waterloo is said to have been heard at Heathfield (Sussex), as well as at Sandgate, Hythe and Ripple Court (between Dover and Deal), at Sandgate very heavy firing being heard throughout the day to the eastward. Heathfield is about 184 miles from Waterloo, Sandgate 144, Hythe 147 and Ripple Court 135 miles. Accounts are also quoted from Pepys' Diary on the sounds of the battle of Solebay being heard in London (about 100 miles), and, from the *Gentleman's Magazine*, of almost incessant heavy firing from Tournay being audible at Brean, Waltham, Brabourne and on other high lands in Kent (about 110 miles), and from the bombardment of Valenciennes at Dover (about 110 miles).

WE have received from Messrs. Lever Bros., Ltd., a translation of a report (which appeared in the *Strassburger Post*) of a lecture on wireless telegraphy, delivered by Prof. Braun at the Institution of Physics of the Emperor William University. Prof. Braun, after giving a short account of the history of the subject, proceeded to describe a system of wireless telegraphy which he had himself worked out. Instead of having a spark gap in the vertical wire, this wire is coiled at its lower end and oscillations are set up in it by induction from another coil containing the spark gap in which the oscillatory discharge takes place. This method, the lecturer claimed, is in many ways superior to that adopted by Marconi, and enables messages to be sent with more certainty and to a greater distance. The results of experiments that had been made were quoted, in which messages were transmitted a distance of about seventy-five miles, using masts ninety feet high at each end. Experiments on the Marconi system are compared with these, in which the results are certainly not so good as those obtained by Prof. Braun. We may, however, call attention to the announcement made by Prof. Fleming to the Liverpool Chamber of Commerce last week (p. 381) that Mr. Marconi had succeeded in transmitting messages a distance of 200 miles, and that messages could be sent simultaneously in both directions, and two or more could be received at once at each station. These results are extremely good, especially as they show that the difficulties of interference of one message with another have been partially, if not wholly, got over. We do not learn from the report of Prof. Braun's lecture whether he has succeeded in avoiding these difficulties in like manner.

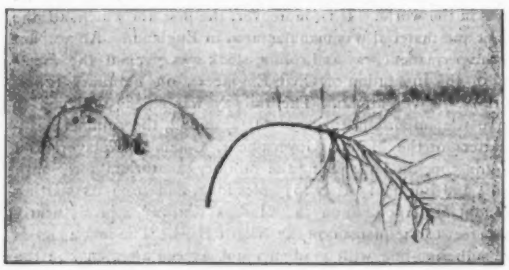
THE Government of New South Wales knows how to appreciate scientific information, and use it for the good of the Colony better than some Governments nearer home. A number of excellent pamphlets on the natural resources and industries in New South Wales have been prepared by Mr. T. A. Coghlan, Government Statistician, and distributed by the Agent-General for the Colony. A pamphlet on the timber resources shows that few countries have such a wealth of timber as New South Wales. Its woods are as varied as they are valuable, ranging from the ironbarks, unsurpassed for work requiring hardness and durability, to the kinds suitable for the most delicate specimens of the cabinet-maker's art. Forestry is, however, as yet only in its initial stages in New South Wales, though it is hoped that a School of Forestry will be established in the Colony before long. The importance attached to the diffusion of knowledge of agriculture is evidenced by the existence of a special Department of Agriculture. The central establishment possesses an experimental farm having a total area of 3430 acres, in addition to which there are several other large experimental farms and plantation trial stations. The agricultural position and outlook of the Colony are described in a separate pamphlet. Another pamphlet, on the climate of New South Wales, contains a large map of Europe having upon it the names of towns in the Colony placed beside European towns of corresponding mean temperature. Bourke, for instance, is placed by the side of Messina, Bathurst with Bordeaux, Cooma with Ventnor, and Kiandra with Edinburgh. Two other pamphlets deal respectively with the fauna and the mining industry of New South Wales. The whole series is commendable, and New South Wales is certainly to be congratulated upon the publication of so much valuable information concerning its resources and progress.

THE Nilgiri Railway is notable as being the first Abt-rack railway constructed in India, and, at present, the longest of its class in the world. It is, moreover, the first for which all the plant and material was manufactured in England. An account of the permanent way and rolling stock was given at the meeting of the Institution of Civil Engineers, on February 12, by Mr. W. J. Weightman. The railway was chiefly designed to serve the important towns of Ootacamund, the summer headquarters of the Madras Government, Coonoor, Kotageri and Wellington, the latter being the military sanatorium for South India and Burmah. It is 16¾ miles long, and from its starting point at Mettapollium on the Madras Railway, ascends nearly 5000 feet to the plateau on the Nilgiri Hills. The first 4¾ miles are adhesion-line with gradients not exceeding 1 in 40; the remaining 12 miles are built on the Abt-rack system, and have a ruling gradient of 1 in 12½. The formation-width is everywhere 16 feet, and as the rainfall is frequently 6 inches in as many hours, the greatest possible care has had to be taken to see that it is effectually drained. The locomotives are of the type known as "combined" Abt engines, that is, they can run either on rack or on ordinary line. Before the line was opened for traffic a series of brake experiments was made with a fully loaded train of 100 tons gross weight. With an ascending train at speeds of 6, 8 and 10 miles per hour on a 1 in 12½ gradient, stops were made in 24, 36 and 60 feet respectively; with a descending train at various speeds ranging from 4 to 12 miles per hour, relative stops were made in 54 feet, increasing to 425 feet.

A NUMBER of designs of flying machines have recently appeared in the illustrated papers. The *Graphic* for January 12 contains a figure of a kind of combination of ice boat and flying machine, attributed to an Austrian engineer named Kress. The arrangement of the aerocurves one behind the other would appear, according to Chanute's experiments, to detract from the lifting power of the hind ones. In the *Black and White Budget* for January 26 occurs the figure of a so-called "auto aviator," due to M. Firman Boussan. It is said to be surmounted by a vertical oblong balloon, thus resembling Dr. Danilewsky's balloon, to be provided with curved wings and propellers, and to be provided with wheels by which it can run

on the roads. Mr. G. L. O. Davidson's name has also recently figured in several papers in connection with the problem of artificial flight, and illustrations of one of his models appear in the *Scientific American* for February 2. The model in question is a bird-shaped glider, the tail of which has movable parts provided with automatic mechanism for regulating the balance and stability. It appears to have glided satisfactorily, but we do not gather from the journal in question that Mr. Davidson has himself performed glides through the air or experimented with motor-driven models. M. Santos Dumont has been experimenting with a motor-propelled balloon, weighing altogether not more than 250 pounds; but the only performance of which we have read consisted in the maintenance of a relative velocity of seven miles an hour for half a minute.

During a severe sleet-storm over a large tract of the northern United States, including Missouri, the water froze as it fell, forming such a heavy coating of ice upon the trees that many of them were bent to the ground by the load, as shown in the accompanying illustration from a paper by Dr. H. von Schrenk, in the *Transactions* of the Academy of Science of St. Louis. The tree in the foreground is a soft maple (*Acer dasycarpum*), likewise the row of trees of which it is one. The trees at the left are birches (*Betula alba*). The tops of the maples scraped on the snow of the street, and is was impossible for one person to lift the top of a tree, much less to restore it to its original position. These trees are good instances of the appearance of the trees all over the affected area; they remained in the bent



position until the ice melted a week later, when the maples returned nearly to their original position and the birches stood quite upright as they were before the storm. Dr. Schrenk weighed about two hundred branches, taken from various trees, and he found that the ice-coated branches of the maples were nearly ten times heavier than the same branches without the layer of frozen water upon it. When the branches bore icicles the ratio was much greater, in many cases the weight being about thirty times greater than that of the branches without ice.

Dr. E. Levst has published in the *Bulletin* of the Imperial Society of Naturalists of Moscow an elaborate discussion of the daily range of barometric pressure at that place deduced from hourly observations, and has compared the results with those obtained from earlier observations and with observations made at St. Petersburg. The values of the harmonic analysis coincide generally with those deduced in the laborious discussions of Dr. Buchan and Dr. Hann. One of the important points of the discussion is the conclusion that the daily range at Moscow appears to have undergone a secular change in so far that the extremes of the daily curve occur earlier than was the case some thirty or thirty-five years ago.

The vitality of certain micro-organisms, both pathogenic and otherwise, in milk under various conditions, forms the subject of an elaborate memoir by Messrs. F. Valagussa and C. Ortona, of the Hygienic Institute of the University of Rome, published in the *Annali d'Igiene Sperimentale*. The action of sunlight on bacteria in milk was investigated, and, as was only to be expected, in consequence of the opacity of the liquid no deleterious effect was detected, except in the case of those varieties which live on the surface of liquids and were, therefore, not shielded from the bactericidal action of sunshine. Another point of interest investigated was the effect of its inoculation into milk upon the elaboration of toxins by the diphtheria bacillus. It was found that although this bacillus does produce toxin when growing in milk, its strength is less than when grown in other culture-media; moreover, a marked increase in the strength of the toxin was noted when the cultivations were kept in a cool cellar instead of at the ordinary temperature of the laboratory. The exact thermal death-point of the tubercle bacillus in milk was also reinvestigated, this being a matter on which many different opinions are held. The authors state that exposure to a temperature of 60°, 70° and 80° C. is insufficient to guarantee the destruction of this bacillus in milk. Milk freshly drawn from the cow, with precautions ensuring its sterility, was found to afford a better culture material for bacteria than after it had been artificially sterilised by heating to 100° C. The paper is rendered of additional value by the very carefully compiled bibliography of the existing literature on the subject which is appended, and which makes it of special use to all interested in this section of dairy-bacteriology.

A paper on hermit-crabs allied to *Pagurus bernhardus*, by Mr. J. E. Benedict, is published in vol. xxiii. (pp. 451–466) of the *Proceedings* of the U.S. Museum, and is noteworthy on account of the excellence of the illustrations. Many of the forms described are closely related, but, in the absence of intergradation, they are classed as species rather than races.

Bulletin No. 14 of the Biological Division of the U.S. Department of Agriculture is devoted to a digest of the laws regulating the sale and transport of game in the different States of the union, the authors being Messrs. T. S. Palmer and H. W. Olds. All the States, it appears, are now fully convinced that unless stringent regulations are put in force the game animals and birds of America will ere long disappear for ever. It is satisfactory to learn that every State has now established laws bearing upon the preservation of game, although more general harmony between them might be advantageous. In their preface the authors state that an Act of Congress passed in May last supplements previous laws by prohibiting the shipment from one State to another of birds killed in violation of local laws, and by subjecting birds brought into any State to the regulations affecting native-raised specimens. The need of a compilation epitomising and contrasting the various laws and regulations has been much felt, and this want the present pamphlet endeavours to supply.

The first three numbers of the new volume of *Die Natur* contain a full report of a lecture delivered in November last before the Verein zur Verbreitung naturwissentschaftlicher Kenntnisse in Vienna, by Prof. F. Toula, on the geological history of the Black Sea. The succession of events, beginning doubtfully in the lower or middle Oligocene, and with certainty in the uppermost Oligocene, is traced through nine distinct stages. The paper forms a most useful summary of recent research over an area including much of the eastern Mediterranean, and extending northward and eastward into Russia and Siberia; a considerable proportion of the work, especially that of Russian geologists and hydrographers, being not easily accessible.

According to the *American Museum Journal* for December the search for fossil vertebrate remains in the far West is being prosecuted with as much activity as ever. Fourteen large cases of

mammalian remains from the Upper Tertiary of Texas, and several truck-loads of dinosaurian bones from the Jurassic of Wyoming and the Cretaceous of Dakota have reached the Museum as the result of last season's work. The dinosaurian remains include the skeletons of one large carnivorous form and of another more nearly allied to the iguanodon. In the same journal will be found an account of the collections in the geological department of the Museum and the manner in which they were acquired. The first important acquisition was the Holmes collection from the Tertiary of South Carolina; this was followed, in 1875, by the James Hall collection, which at once placed the Museum in the foremost position among American institutions in regard to Palæozoic fossils.

PROF. PENCK contributes a valuable paper to the *Zeitschrift* of the Berlin Gesellschaft für Erdkunde, on the glacial phenomena of Australia. The evidences of glacial action in different parts of Australia during permo-carboniferous times are discussed in detail, and brought into relation with traces of simultaneous action in India and South Africa; and it is shown that, apart from other difficulties, the hypothesis of a shifting of the South Pole to a central point (on the tropic of Capricorn in long. 86° E.) does not satisfactorily account for the geological facts. It is next pointed out that the appearances ascribed to ice action present in each case certain features not characteristic of ordinary glacial deposits—the deposits are stratified, and the pebbles are facetted in the manner first described by Wynne. Further, the Gondwána beds, always closely associated with these boulder deposits, have lately been found in the Argentine Republic. Prof. Penck compares the bedding and facetting with conditions induced by pressure observed in the Nagelfluh and in certain localities near Vienna, and concludes that while many indications certainly point to glacial action, these special points must be fully investigated before the formidable problem of accounting for the existence of glacial conditions over such an enormous area can be attacked. The second part of the paper summarises present knowledge of the quaternary glacial, or glacier, period in Australia and New Zealand, and compares the probable elevation of the snow-line in Australia and western Europe in quaternary and modern times.

MESSRS. J. J. GRIFFIN AND SONS have just introduced a new form of balance which should find a place on many lecture tables. The instrument is large enough to be seen clearly by a large class, and it can be manipulated by the lecturer without standing in front of it. The sensitiveness, rate of swing, length of arm and other characteristics can be altered so as to illustrate the principles of construction of a balance.

A PAPER by Messrs. K. A. Hoffman and E. Strauss on "radioactive lead" appears in the current number of the *Berichte*. This material is extracted from various minerals such as pitchblende, cleveite, broggerite, copperuranite, samarskite and euxenite, and resembles lead in being precipitated from its acid solution by sulphuretted hydrogen, in forming a sulphate insoluble in dilute sulphuric acid, and in having a yellow iodide. It differs from lead in the fact that it acts upon a photographic plate in the dark; it possesses a characteristic violet line in its spark spectrum, and its equivalent is markedly different, being 65·05 as against 51·7 for lead. The authors regard their results as being due to the presence of an element of an atomic weight of over 260, probably either divalent or tetravalent.

IN a recent contribution to the *Proceedings* of the American Academy of Arts and Sciences, Prof. Richards, of Harvard, expresses the opinion that the formal sanction of an international table of atomic weights is only a matter of a short time. The opinion elicited by the Commission of the German Chemical Society is overwhelmingly in favour of O=16·00 (H=1·01) as against H=1 (O=15·88), though some eminent authorities would adhere to the old standard. The second question put by the German Commission, as to whether the last figure set down in an atomic weight should be correct to within half a unit, is also answered in the affirmative by a large majority. From this consensus of opinion Prof. Richards is a dissentient, and he explains his position by reference to the case of nitrogen. The International Committee constituted through the German Chemical Society appears already to have made its decision, for in the first number of the *Berichte* for the present year there are inserted two tables of atomic weights, one of which is headed "Internationale Atomgewichte." In this the basis is O = 16·00(H = 1·008), and the numbers given are accurate to one unit in the last place. The second table issued with the *Berichte* is of "Didaktische Atomgewichte" to the basis H = 1·00(O = 15·88). It is obviously intended to meet the objections of teachers who foresaw difficulties in having to explain the use of 16 as the basis of a numerical system for atomic weights and densities. Opinions will differ as to the wisdom of having two tables current, but in any case they need not both be adopted by the same person. It would be hard for a teacher to have to remember that in the class-room S was 31·83, whilst in the laboratory it was 32·06. It is probable that most didactic requirements will be satisfied with S = 32.

THE additions to the Zoological Society's Gardens during the past week include a Common Guinea Fowl (*Numida meleagris*) from Morocco, presented by Mr. G. E. Veroutsos; fourteen Tree Frogs (*Hyla*, sp. inc.) from Barbadoes, a Capuchin (*Cebus*, sp. inc.) from South America, a Black-handed Spider Monkey (*Ateles geoffroyi*) from Central America, two Blood-rumped Parrakeets (*Psephotus hoematonotus*) from Australia, deposited; an August Amazon (*Chrysotis augusta*) from Dominica, four Banded Grass Finches (*Poëphila cincta*) from Queensland, two Arizona Heloderms (*Heloderma suspectum*) from Arizona, U.S.A., purchased.

OUR ASTRONOMICAL COLUMN.

REDUCTION OF OBSERVATIONS OF EROS.—In anticipation of the conclusion of the work on the planet Eros during the recent opposition, Prof. G. C. Comstock, of Washburn Observatory, U.S.A., contributes a note to the *Astronomical Journal*, No. 490, on the limits available in the necessary reductions. The question of reducing micrometer measures depends on the degree of accuracy with which it may be assumed that the mean of a number of settings represents the positions of the planet and comparison stars at the mean of the observed times. The problem is discussed with respect to three independent sources of changes in the observed coordinates.

(*a*) *Geocentric motion.*—General result is that if a set of measures does not extend over a period greater than one hour, the planet's motion may be treated as uniform, with a probable error of ± 0″·01.

(*b*) *Parallax*, which changes with the observer owing to the diurnal motion. In this case the interval allowable is less than half an hour.

(*c*) *Differential refraction*, varying with the time of observation. For this element a table is given showing the correction introduced for varying zenith-distances.

CONSTANT OF ABERRATION.—The results of zenith-telescope observations of latitude at the Flower Observatory, University of Pennsylvania, are given by Mr. C. L. Doolittle in the *Astronomical Journal* (No. 490).

The correction to Struve's aberration constant was determined from these observations and applied to the final reductions. The following values of the constant have hitherto been derived:—

1892–1893	...	20″·552	...	at Bethlehem.
1894–1895	...	20·537	...	,, ,,
1896–1898	...	20·580	...	,, Philadelphia.
1898–1900	...	20·542	...	,, ,,

HARVARD COLLEGE OBSERVATORY.

THE fifty-fifth annual report of the work done at the Astronomical Observatory of Harvard College during the year ending September 30, 1900, has recently been circulated by the Director, Prof. E. C. Pickering, and is here summarised.

Observatory Instruments: *East Equatorial.*—The observations with this instrument were made by Prof. O. C. Wendell; during the year 24,000 photometric light-comparisons were made, principally with the achromatic prism polarising photometer. Over 15,000 of these were series of measures of twenty variables.

This instrument, with a second photometer adapted to stars nearer together, has been used for determination of the following:—

	Comparisons.		Comparisons.
o Ceti	1792	β Lyræ... ...	848
U Camelopardali.	160	Nova Aurigæ ...	96

and also in the photometric measurement of Jupiter's satellites while undergoing eclipse, eighteen eclipses having been observed; the satellites of Saturn, Japetus and Titan; the light of the planet Eros (224 settings), and in addition the systematic photometric observations of variable stars of long period have been continued.

Meridian Circle.—The ruled glass plate with which former determinations have been made for the last ten years has been replaced by spider lines, and the declination micrometer employed in conjunction for the first time. From the new observations a comparison is to be made between the accuracy obtainable by the two methods. The work of the instrument has been mainly confined to determinations of clock error and instrumental constants. The reduction of the observations made by the late Prof. Rogers from 1879–1883 is being continued.

12-inch Meridian Photometer.—With this instrument 79,024 settings were made by the Director on 140 nights. The first large work, comprising the observation of all the stars contained in the Durchmusterung, in zones 10′ wide and 10° apart, is now practically completed; the total number of stars is 9233, 6195 of which are fainter than the ninth magnitude. Good progress has been made with the reductions.

Meridian Photometer.—The observations of the stars south of declination −30°, of magnitude 7·0 and brighter, were completed early in December at Arequipa. Forty-four series were taken, involving 13,244 settings. The instrument was then sent to Cambridge, mounted, and electric light substituted for gas. A catalogue of standard stars, one in each 10° square, has now been prepared, and 16 series, including 6424 settings, have been made by Prof. Bailey.

Henry Draper Memorial.—Six hundred and eighty-nine photographs have been obtained with the 11-inch Draper telescope, and 2187 with the 8-inch instrument. The examination, by Mrs. Fleming, of the spectra on these plates and on those taken with the Bruce and Bache telescopes has led to the discovery of fourteen new variable stars, ten of which contained bright hydrogen lines in their spectra, and six are gaseous nebulæ. Eight variables have also been discovered in other ways. A new star in Aquila was found from examination of photographs, making the sixth object of this class detected in this manner.

In the study of the spectra of bright southern stars, it has been found that Hδ is bright in A.G.C. 8991, and variable in the two stars A.G.C. 19737 (η Centauri), and A.G.C. 20,878 (α^2 Apodis).

Experiments are in progress for determining the photographic magnitudes of stars by the measurement of images out of focus, whereby a comparison is made of *surfaces* instead of *points*. It is found that stars can be measured in this way at the rate of five a minute, with a probable error of a tenth of a magnitude. Some 14,000 measures have been made in this way. For special purposes, charts are now being regularly taken with the 8-inch and 11-inch Draper telescopes, without following, by varying the rate of the clock and the position of the polar axis. A small telescope is rigidly attached to the base of the 11-inch telescope and directed toward two distant scales placed at right angles to each other, thereby permitting the axis to be set in any desired position rapidly and accurately. A photograph of the planet Eros was obtained in this manner on July 28, 1900, in which the image was sensibly round, although the exposure lasted 153 minutes.

Photographs of star occultations and eclipses of Jupiter's satellites have been obtained on several occasions.

Boyden Department.—As the sky was so clear at Arequipa during the latter part of 1899, it was unnecessary to remove the meridian photometer to the Desert of Atacama, Chile, as had been anticipated. Great delay has been experienced in the transmission of the plates to and from Peru, partly due to the quarantine consequent on the prevalence of fever along the west coast. The number of photographs taken with the 13-inch Boyden telescope is 201, and with the 8-inch Bache 2054.

Three hundred and fifty-eight visual observations of 48 southern variables have been made by Argelander's method. Systematic examination of all the stars south of declination −30°, between the magnitudes 6·3 and 7·0, inclusive, for the detection of new double stars, has been continued; 541 stars have thus been examined, leaving a further 450 requiring observation.

Meteorological Observations.—Observing stations have been maintained during the year at eight localities having altitudes varying from 100 to 19,200 feet; but great difficulty has been experienced at the lofty mountain stations.

These observations have now been continued for eight or nine years; taking into consideration, however, the striking uniformity of conditions which prevail in different years in this region, it is probable that additional observations would not greatly increase knowledge, and it has therefore been decided to suspend the meteorological observations of all the stations, except those at Arequipa. This seems to be a great pity, for nine years is a very short period when meteorological data are in question, and especially when the altitudes of the stations are so different.

The Bruce Photographic Telescope.—Seven hundred and sixty plates have been taken with this instrument during the year. From 319 of these 198 new faint nebulæ have already been detected. On these plates thus examined have also been found 92 asteroid trails and 2 meteor trails. In the spring of 1900 successful photographs of Eros were obtained by a special method when the object was too faint for ordinary procedures. The photographic plate was moved during exposure at the rate calculated for the motion of Eros relative to the diurnal motion. Three good plates were thus obtained on April 28, 30, 31, 1900.

A long series of photographs of Saturn was taken, to determine, if possible, the orbit of the satellite Phœbe. From an examination in Arequipa the existence of this object has not been confirmed; a careful examination will again be made on the arrival of the plates at Cambridge.

Blue Hill Observatory.—The chief work here has been the continuation of the exploration of the upper atmosphere by means of self-recording instruments carried by kites. The greatest height attained was 15,800 feet.

Miscellaneous.—(1) The scheme of distribution of important astronomical news is now greatly appreciated. Twenty bulletins have been issued during the year. These are sent gratuitously to all who desire them, and telegrams will be sent on payment of official fees.

(2) The long focus telescope obtained last year, with aperture of 12 inches and focal length of 136 inches, was lent to Prof. Langley, of the Smithsonian Institution, for photographing the corona during the eclipse of the sun in May 1900, the results being highly satisfactory.

(3) By the aid of an appropriation from the Rumford Fund of the American Academy, an important investigation has been started for the determination of standards for faint stellar magnitudes. For this work telescopes of 40, 36, 26, 15 and 12 inches aperture will be used, by the generous co-operation of the Yerkes, Lick and McCormick observatories with that of Harvard.

(4) A considerable number of photographs of the planet Eros have been taken, but as it is considered that the present opposition will not afford improved values of the solar parallax, it is doubtful if they will all be measured, unless the number obtained elsewhere be insufficient. Considerable care will, however, be taken in determining the variations of the light of the planet, both photographically and visually.

Establishment.—Prof. Pickering marks the completion of the work of the Observatory for the nineteenth century by giving a detailed account of the needs of the institution and the conditions of those portions of its work which are at present unfinished. The annual income is nearly 10,000*l.*, but this is required for current expenses. The estimated value of the buildings and instruments at Cambridge is about 15,000*l.*, and at Arequipa about 12,000*l.*

The main building at Cambridge is of wood, more than fifty years old, and the whole, including the invaluable astronomical library, is in constant danger of destruction by fire. The estimated cost of new modern buildings is about 20,000*l*. A large telescope for work at present entirely neglected in the southern hemisphere could also be obtained for a further 20,000*l*.

A long list of the principal unpublished investigations is given, most of which are ready for completion if means be forthcoming. These will occupy about twenty-eight volumes of the *Annals*, *i.e.* almost two-thirds as many as have already been published during the half-century of the existence of the Observatory.

SCIENCE IN TECHNICAL AND PREPARATORY SCHOOLS.[1]

EDUCATION is probably more discussed at the present time than ever it was before. It has become a subject for the newspapers, and to some extent for the political platform. It would seem there is now really a hope that the ordinary man of affairs will soon appreciate its importance. The advocates of education in science and technology have for years appreciated the reality and understood the reason of successful foreign competition, and now the lesson is being impressively driven home to every manufacturer by the tale of diminishing exports. Facts such as these give the recent report, made for the Department of Special Inquiries of the Board of Education by Mr. James Baker, on technical and commercial education in East Prussia, Poland, Galicia, Silesia and Bohemia, a very high value. Written as it is from the point of view of a skilled observer generally interested in the development of British industry and commerce, the report will receive more careful attention from the practical men engaged in manufacture than would the opinion of a mere student of pedagogics.

With the exception, perhaps, of the part of Russia he visited, though even there some progress is being made, Mr. Baker tells of the rapid advances he found have taken place everywhere in the development of technical and commercial education. And, what is of particular importance to us in this country, he demonstrates that the efficiency of any nation's supply of technical instruction in its various grades depends directly upon the satisfactoriness or otherwise of the national supply of primary and secondary education. It is that student alone who has received a thorough and suitable grounding in preliminary subjects who benefits by the specialised instruction of the trade school and technical college.

But this cause by itself is not sufficient to explain the high standard of foreign systems of technical education. In Prussian Poland and in parts of Austria the want of continuity between the work of the day schools and the higher technical studies of the trade schools has been abolished by legislation. In this country attendance at school during the years of apprenticeship is optional, with the result that even if the young workmen ever reach the classes specially designed to instruct in particular industries they have forgotten completely, by that time, their elementary knowledge; in the countries named, however, attendance at evening continuation or other schools is as compulsory as that at the ordinary day school. For instance, in describing the provisions for technical instruction at Posen, a town of 100,000 inhabitants in Prussian Poland, Mr. Baker writes of the Fortbildungsschules (continuation school, and the Gewerbschule or trade school: "This is for learners in all handicrafts. There is no payment, but the apprentices in all trades are compelled to attend this school under penalty of fine or even imprisonment. Lads commence here at fourteen and continue until eighteen, attending two afternoons a week and in the evenings. The employers are compelled to give their apprentices two afternoons a week, unless they are engaged upon work outside the town, when the lads are excused from attendance." Similarly, in connection with Trautenau, the Bohemian flax centre, with 16,000 inhabitants, we find: "Here all the apprentices must attend the trade continuation classes, which are held from six to eight in the evening and from eight to twelve a.m. on the Sunday. . . . In the Commercial Continuation School the same applies to business apprentices." And similar examples could be multiplied.

But it is impossible to manufacture, by any system of compulsion, enthusiastic students anxious to master everything known about the science of their trade and filled with a desire to improve upon the methods generally adopted. Continental authorities recognise this. It may be possible to raise the average ability of the workmen by enforced attendance at evening schools, but to discover the specially endowed craftsman who will repay all the trouble taken to place opportunities in his way, other plans are adopted. Here is one, expressed in Mr. Baker's words: "There is one great leverage the German schoolmaster possesses wherewith to lift his pupils into good work that an English teacher does not possess, and that is the fact, if a certain grade of work is passed, the student is freed from one or two years of military life, becomes a 'volunteer,' and only serves one year." But it is only in exceptional cases that this rule applies in Austrian towns, at all events in the lesser towns. Another means of attaining the same object is very common. In those schools which have not the right to exempt their pupils from one year of military service, an *Answeis*, or leaving document, is employed, and on this is set forth the progress made, the behaviour and the diligence of the pupil, with a record of the attendance and a list of the subjects studied by the young man. This record has to be produced when the youth is called up for his time with the colours, and if the report is bad he may have to serve three years instead of two.

This subject of compulsory military service brings into high relief one great advantage the British workman has over his Continental contemporary in point of time. Mr. Baker writes eloquently in this connection: "In going through these technical schools I saw young men working at the most delicate handicrafts; they had just arrived at excellency; their skilled hands, guided by a highly cultured brain, were turning out work most delicately artistic; but they must lay down their tools and take up sword and rifle for two years, or three if in the cavalry or artillery; their hands must forego the exercise of their cunning, if they do not lose it altogether; . . . Herein is the Englishman's opportunity when he obtains the same advantages of education as the Austrian or German; he can at once leap ahead of his Continental competitor, for he gains these two years given up by the Continental to military service."

But perhaps the most remarkable characteristic of Austrian technical education is the extent to which decentralisation has been carried throughout the country. While making due provision for advanced work in a few large centres, the object of the authorities seems to be to bring suitable instruction in the technology of the particular industry of a district to the very doors of the workers. A notable instance of this, and it is typical, is the case of Turnau, or Turnov, the jewellers' town. It is a little place of 6500 inhabitants, whose chief industry is goldsmiths' work and the polishing and setting of jewels. Here has been established a Royal Imperial trade school for jewel cutting, polishing, engraving and setting in gold, but in addition to this technical institute there are four Volksschulen (primary schools), a Bürger school, and a continuation school in winter for handicraftsmen. The students of the Royal Imperial trade school come direct from the Volksschulen, beginning this special work at fourteen and remaining for four years. The tuition is free, but the lads receive no pay. The total number of pupils in the school is seventy-eight, and they are all being converted into cultured artisans. When they pass out of the school they are given a leaving certificate, which confers the full status of a workman and ensures treatment as an educated man for the holder.

The question naturally presents itself, What manner of men are in charge of institutions the object of which is to produce accomplished artisans who are also at the same time educated in a higher and more general sense? On this subject, too, the report under consideration supplies abundant information. In the description of the technical college at Prague a short life-sketch of Director Edward Cerny is given. He bears the title, by the way, of Royal and Imperial Councillor—a proof of the esteem in which men of science and educational leaders are held in Austria, where, as in Germany, such authorities are commonly nominated Privy Councillors, and receive titles and decorations. It is impossible in a short article to refer to all Director Cerny's qualifications; it must suffice to say that his case is quite general and that the common rule is to appoint

[1] Report on Technical and Commercial Education in East Prussia, Poland, Galicia, Silesia and Bohemia. By James Baker, 122 pp. Board of Education Special Reports on Educational Subjects. Volume vi. Preparatory Schools for Boys: their Place in English Secondary Education. 531 pp.

"practical engineers or business men, thus bringing to bear on their teaching, not only the general education gained at school and their thorough knowledge of theoretical science, but also their practical experience of the workshop and business life."

These are but a few of the vital questions with which this valuable report is concerned. We heartily commend the volume to all who are interested in improving the home supply of technical education until it is not only on a level with that of Germany and Austria, but well in advance.

When we turn to the second of the reports, that concerned with the place in English secondary education of preparatory schools for boys, we are confronted with another stage in the preparation of the citizen for the duties of life. As every one knows, probably, the preparatory school undertakes the education, up to about fourteen, of the boy destined for our great public schools. Generally, after some five years at the public school, this fortunate son of well-to-do parents proceeds to either Oxford or Cambridge to continue his education. It is interesting to inquire as to the share science takes in the work of a preparatory school. It may be stated parenthetically that in a volume of 531 pp. only some sixteen pages are devoted to the teaching of mathematics and natural science together, though it is true nine of the sixteen are given to the latter.

It must be said at once that any science teaching at all in preparatory schools is the exception rather than the rule. To quote Mr. Archer Vassall, of Harrow, who deals with the subject in the official publication before us, "tentative efforts in scientific instruction have been made, and are still in progress at many of them"—and that is all that can be said. But there is nothing surprising about this. Since the sole function of the preparatory school is to prepare for the public school, those subjects only which are in demand in the second will be taught in the first, and, to quote Mr. Vassall again, "in public schools the teaching of science has only recently begun to take reasonable shape," a condition brought about by the regulations governing the award of University scholarships. So that to ensure an improved condition of things in the preparatory school men of science must bend their efforts towards securing reforms at Oxford and Cambridge.

Mr. Vassall's short article is chiefly concerned with a sketch of a suitable preparatory school course in natural science. In common with modern ideas he insists upon the need of individual practical work, and very properly urges that the study of science might well begin with what he calls "kindergarten physics." This mode of procedure has for some years been followed in higher grade boards schools, and in those other secondary schools which have adopted the syllabus of the Headmasters' Association. But we think Mr. Vassall is wrong in excluding chemistry from his preliminary course, for there are many excellent exercises which are in no way dangerous. Anyhow, a beginning has been made with science in preparatory schools, and if the masters will acquaint themselves with the results of experience in schools of other grades, we shall soon hear that science has gained for herself a more honourable place.

A. T. SIMMONS.

THE FIGURE OF THE EARTH.[1]

THE United States Coast and Geodetic Survey has just published a quarto volume containing an account of the transcontinental triangulations and measurements of an arc of the parallel in latitude 39°. It also has ready for publication the manuscript giving the result of an oblique arc in the eastern part of the United States. Both are contributions of great length and among the first of their kind in America.

Before entering upon the detail of the two arcs it may not be out of place to state that in order to obtain a measure of the dimensions of the earth, as represented by a spheroid, that is, by a surface generated by the rotation of an ellipse about its minor axis, it is essential that we should be in possession of at least two arcs or of an equivalent thereof. For combinations of two arcs of the meridian, their mean latitudes should differ widely; the same is true for the combination of two arcs of the parallel. We may also obtain an arc of the meridian with one of the parallel, but in every case the measures should be of considerable extent. Arcs of less than 5° (about 556 km., or 345 st. miles) would now be regarded as short ones. It has been stated that one of the arcs is an oblique arc, and as it possesses a great range of latitude and also of longitude and is supplied with a large number of astronomical measures, it is of itself sufficient for the deduction of values for the dimensions of the earth. Furthermore, it may be remarked that for any relatively small part of the earth's surface an osculating spheroid may be determined, as, for instance, was done for our oblique arc. Such a spheroid has the property that its surface is in best accord, as regards curvature, with the actual or physical one, the latter considered as a mathematical surface of equilibrium and generally known as geoid.

The definition of an osculating spheroid thus implies that the sum of the squares of the difference between the various astronomic and geodetic measures be a minimum. The mathematical treatment of the combination of the arc measures differs according to their nature, whether they are extended in a certain direction or whether large areas are covered, but in its generality it is necessarily laborious.

The salient points of the two arcs measured by the U. S. Coast and Geodetic Survey and the results reached may now be briefly stated. First, the arc of the parallel in latitude 39°.[1] It extends from Cape May, N.J., on the Atlantic coast, to Point Arena, Cal., on the Pacific coast, and ranges over 48° 46′ of longitude, with a linear development of about 4225 kilometres, or 2625 st. miles. The triangulation is supported by ten base lines with an aggregate length of 53½ st. miles, the longest or Yolo base being 10·9 miles in length, one half of these lines having a smaller probable error of measure than one part in a million. A characteristic of the triangulation is its rigidity imparted to it by quadrilaterals and other polygons. In crossing the Rocky Mountains, many of its sides exceed one hundred miles in length, and there is one side reaching to a length of 294 km., or 183 st. miles; the altitude of many of the stations is also considerable, reaching to 4300 metres, or 14 108 feet, in the case of Pike's Peak, and to 14,421 feet at Mount Elbert. All geometrical conditions subsisting in the triangulation are satisfied by adjustment, inclusive of the required accord of the base lines, so that the same length for any given line is found no matter from what line one may start. This involved much heavy work; for instance, the triangulation adjustment between the Salina and the El Paso base demanded the simultaneous solution of ninety-nine normal equations (with as many unknowns). In addition, the figures required the evolution of a correction to each of the two hundred and twenty-five observed directions.

Coming to the astronomical measures, we have distributed over or near the arc one hundred and nine latitude stations, occupied almost exclusively with zenith telescopes; there are, also, seventy-three azimuth stations, various methods having been used, and lastly we have twenty-nine telegraphically determined longitudes. These, of course, are of paramount importance for an arc of the parallel. There cannot be too many longitude stations in consequence of that great stumbling-block in geodesy, the local deflections of the vertical or plumb-line. These deflections of the zenith from a normal direction have been divided into two groups—those which are regional or manifest themselves with marked common features over thousands of square miles, and those which are quite local and greatly depend upon the surface features immediately surrounding them.

These deflections, even in level countries, average about 2·5″; but in mountainous regions this deflection is greatly surpassed. Thus we find for deviation of the plumb-line at Patmos Head station 12″ to the north, at Colorado Springs 25″ to the west, at Salt Lake City about 17″, and at Ogden about 15″ to the east, at Genoa Station, Nev., nearly 29″ to the west, the quantities depending to some extent on the spheroid of reference; but their amount and direction are obviously well accounted for by the position of known attracting masses. In connection with this, continental attraction may manifest itself and be recognised by the astronomical amplitude of the longitudes of extreme stations of a long arc being in excess of the corresponding geodetic amplitude. The matter cannot be further pursued here in detail, but it may suffice to state that the average curvature of the equipotential surface of the geoid along the parallel of 39°

[1] Abridged from a paper on recent contributions by the United States Coast and Geodetic Survey to our knowledge of the earth's shape and size, by Mr. C. A. Schott, in the *National Geographic Magazine*, New York.

[1] U. S. Coast and Geodetic Survey; H. S. Pritchett, Superintendent. The Transcontinental Triangulation and the American Arc of the Parallel. By C. A. Schott, Assistant, Coast and Geodetic Survey, Washington, D.C., 1900.

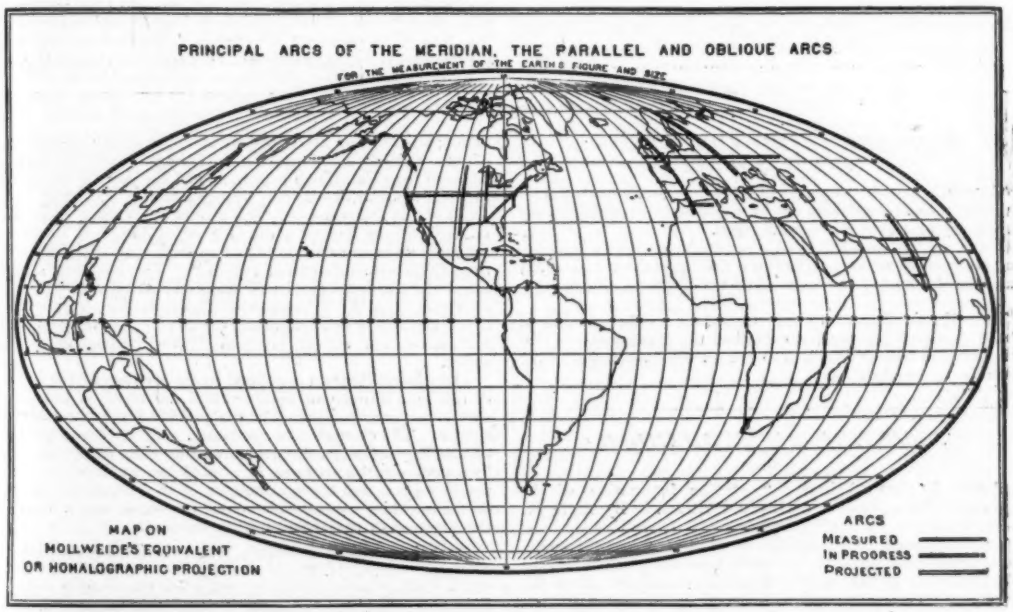
approaches for about four-sevenths of the arc from its eastern end closely to that of the Clarke spheroid; whereas, for the remaining three-sevenths, or for the region across the Rocky Mountains to the Pacific, the curvature comes more nearly to that of the Besselian spheroid. In the published paper two tables are given containing the results needed for combination with any other arc and, in conclusion, some preliminary rough combinations of American arcs are presented; all of which point to a reference spheroid of larger dimensions than those of the Besselian and are in favour of continuing the use of Clarke for reference.

The second arc under consideration extends from Calais, Me., in the north-east and opposite the Canadian boundary, to the Gulf of Mexico, and terminates at New Orleans, La. It is known as the Eastern Oblique Arc of the United States. Its length is 2612 km., or 1623 statute miles; its difference of latitude is 15° 1′, and of longitude 22° 47′. The general direction is therefore favourable, and the length ample to secure fair results for an osculating spheroid. In the main the triangulation follows the Appalachian chain of mountains; in Western North Carolina and Eastern Tennessee it bifurcates, leaving an oval space between the two branches. The length of sides depends upon six base lines, and in general the development is closely accommodated to the hypsometric and other natural conditions along the course. It includes among its stations the two highest points in the eastern part of the United States, viz. Mount Washington, N.H., rising to about 1920 metres, or 6300 feet, and Mount Mitchell, N.C., rising to about 2038 metres, or 6687 feet.

The adjustment of the whole triangulation is effected precisely as explained in the use of the arc of the parallel; the small reduction to the sea-level of the observed horizontal directions, on account of the altitudes sighted, was only applied when exceeding 0·05″. The principal labour of adjustment was demanded by the necessity of bringing into accord the measured lengths of the Fire Island, the Massachusetts and the Epping base lines, and fulfilling the geometrical conditions of the intervening net of triangles. This demanded the satisfying of fifty-seven conditions and involved the simultaneous solution of an equal number of normal equations and the working out of 131 corrections of observed directions. Of astronomical measures we have seventy-one latitude stations, seventeen longitude stations, and fifty-six azimuth stations, tolerably well distributed over the whole extent of the arc. The latitudes, as were those of the arc of parallel, were corrected for height of station or curvature of the vertical and for variation of pole according to Dr. Chandler's and Dr. Albrecht's researches. The same scrutiny as before had been extended to the deflections of the vertical, both regional and local. Partly on account of avoiding unnecessary labour, but principally on account of the crowding together of astronomical stations in certain very limited localities, and all of them, therefore, partaking of the deflections characteristic of this area, the total number of astronomical stations admitted into the final equations for the determination of the best spheroid were thirty-six for latitude, fourteen for longitude, and thirty-four for azimuth, or eighty-four conditions in all.

These eighty-four differences between the astronomical and geodetic results constitute the data needed for a new determination of a spheroid; next the functional relations between the positions of these stations upon the reference spheroid to the earth's equatorial radius and to the compression of the polar axis had to be established.

The final normal equations contain, therefore, four unknown quantities, viz. the correction to the meridional deflection of the vertical at the initial or reference station of the oblique arc; second, the corrections to the deflection of the vertical, in the plane of the prime vertical, at the same place; third, correction to the equatorial radius of the reference spheroid; and, last, the correction to its compression.



In the combination of conditional equations arising from observations of a different nature, the question of their relative weights must be considered. In the present case, four assumptions were made and the consequent normal equations solved, viz. for equal weights, for weights one-half, one-third and one-fourth to the azimuth equations, the latter being necessarily inferior to the equations derived from latitudes and longitudes. A comparison of these four results showed that it was of small consequence which of these hypotheses was finally adopted, since the corrections to the equatorial radius of the reference spheroid were practically the same for any of these hypotheses, and nearly the same could be said of the resulting compressions. The weight one-third to each of the azimuth equations was finally decided upon, and the resulting dimensions of an osculating spheroid were found to be:—Equatorial radius, 6,378,157 ± 90 metres; compression, 1/304·5 ± 1·9. The equatorial radius, therefore, differs but 49 metres from Clarke's value of 1866 adopted on the Survey, while the Besselian value is apparently too small by 809 metres. On the other hand, the compression or the ratio of the difference of the equatorial and polar semi-axes to the former is in favour

of Bessel's spheroid, of which the compression is 1/299·2; that is, one more closely approaching a sphere.

In the present state of our knowledge there is no reason to suppose that the curvature of the northern part of America differs any more from that of a general spheroid derived from arcs of all kinds so far measured than local ones in either hemisphere differ among themselves. A comparison of a number of such locally adopted spheroids will bring to evidence the local deformities in the shape of the earth's equilibrium surface and furnishes the geodesists endless material for the study of the earth's actual figure.

The manuscript concludes with a comparative table of the dimensions of several spheroids which of late have come more into prominence. It is as follows :—

Spheroid of	Equatorial radius, a, in metres.	Polar semi-axis b, in metres.	$a-b$.	Compression $(a-b)/a$.
Bessel, 1841. From ten arcs of the meridian and total amplitude 50° 34′	6,377,397	6,356,079	21,318	1/299·15±3·15
Clarke, 1858. Special spheroid for surface of Great Britain and Ireland; range of latitude 12°, the same in longitude; seventy-five astronomic stations	6,378,494±90	6,355,746	22,748	1/280·4±8·3
Clarke, 1866. From five meridional arcs, of total amplitude 76° 35′	6,378,206	6,356,584	21,622	1/295·0
Clarke, 1880. From five meridional arcs and longitudinal measures, total amplitude 88° 59·8′ (equatorial degrees)	6,378,249	6,356,515	21,734	1/293·5
United States Coast and Geodetic Survey, 1900. Eastern oblique arc of the United States; total length, 23° 31′, and eighty-four astronomic stations	6,378,157±90	6,357,210	20,947	1/304·5±1·9
Harkness, 1891. From "The Solar Parallax and Related Constants," Washington, 1891, p. 138. From a variety of sources	6,377,972±125	6,356,727±99	21,245	1/300·2±3·0

N.B.—The ± indicates probable errors.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—A valuable collection of Greek papyri from Oxyrhyncus and the Fayûm has been presented to the University library by the Egypt Exploration Fund.

Dr. A. C. Haddon, F.R.S, University lecturer in ethnology, and professor of zoology in the Royal College of Science, Dublin, has been elected to a junior fellowship at Christ's College.

THE King's Speech to the Commons at the opening of Parliament on Thursday last contained the announcement that "Legislation will be proposed to you for the amendment of the law relating to education."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 7.—"The Integration of the Equations of Propagation of Electric Waves." By A. E. H. Love, F.R.S.

The equations of propagation of electric waves, through a dielectric medium, involve two vector quantities, which may be taken to be the electric force and the magnetic force. Both the vectors are circuital; and the several components of them satisfy the partial differential equation of wave propagation, viz. $\ddot{\phi} = c^2\nabla^2\phi$, c being the velocity of radiation.

Owing to the circuital relations, certain known solutions of the partial differential equation of wave propagation are not available, for representing the components of the vectors. A very general system of *particular* solutions, which are available for this purpose, is obtained. These include solutions corresponding to two types of sources of electric radiation:—The sources of one type are similar to infinitesimal Hertzian vibrators, being related in the same way to an axis, but the dependence of the emitted radiation on time is arbitrary; the sources of the other type are obtained therefrom by interchanging the *rôles* of the electric and magnetic forces.

The general integrals of the equations would express the values of the vectors, at one place and time, in terms of their values, at other places and times. To find such integrals, we require (1) sets of particular solutions, which tend to become infinite, in definite ways, in the neighbourhood of chosen points; (2) a theorem of reciprocity, connecting the values, on any chosen surface, of two sets of solutions; (3) the limiting form, assumed by the theorem of reciprocity, when the solutions of one system have the assigned character of infinity at a given point. The solutions required for the first step are among those already found; the theorem of reciprocity is obtained by a modification of the process by which the fundamental equations can be deduced from the Action principle; and the limiting form of the theorem is found by adapting a process due to Kirchhoff. The result is that the radiation which arrives at a chosen point may be regarded as due to a distribution of imagined sources of radiation upon an arbitrary closed surface, separating the point from all the actual sources of radiation. The imagined sources are of the two types previously specified; and the directions of their axes, and the intensities of the radiation sent out from them, are determined simply and directly by the values, on the surface, of the vectors involved in the propagation of the waves.

The general theorem is applied to the problem of the passage of radiation through an aperture, and the result is utilised to determine the rate of decay of the vibrations of a condensing system. The example of a condenser, with concentric spherical conducting surfaces, the outer conducting sheet being perforated by a small circular aperture, is worked out in detail; and the results suggest that the maintenance of the vibrations depends on the screening action of the outer conductor rather than on the largeness of the capacity of the condenser.

Anthropological Institute, February 4.—Annual General Meeting.—Mr. C. H. Read, president, in the chair.—On a ballot the following were elected to office for the ensuing year:—President: Prof. A. C. Haddon, F.R.S. Vice-presidents: A. J. Evans, W. Gowland, Prof. G. B. Howes. Hon. Treasurer: A. L. Lewis. Hon. Secretary: J. L. Myres. Council: Sir T. H. Holdich, Sir C. E. Peek, Messrs. G. M. Atkinson, H. Balfour, W. Crooke, Prof. D. J. Cunningham, W. L. H. Duckworth, R. W. Felkin, H. O Forbes, J. G. Garson, E. S. Hartland, T. V. Holmes, E. F. im Thurn, A. Keith, R. B. Martin, M.P., R. H. Pye, E. G. Ravenstein, Prof. W. Ridgeway, W. H. R. Rivers and F. C. Shrubsall. After reading and discussion of the reports of the treasurer and council, the retiring president proceeded to give his address After alluding to the death of Her Majesty Queen Victoria and paying a tribute to Lieut.-General Pitt-Rivers, an ex-president of the Institute, Prof. Max Müller, Miss Kingsley and other distinguished Fellows who had been removed by death, he went on to call attention to the progress made by anthropology, more especially in the British Empire, during the past year. A joint memorial of the Folk-lore Society and the Institute had been presented to the Government, urging the theoretical and practical importance of an inquiry into the status of native races in South Africa. In India, in combination with the census, a scheme for a partial ethnographical survey had been called into existence, over the working of which the Hon. H. H. Risley would preside. He hoped that in England we should soon have chairs of anthropology at all the important teaching

centres; Birmingham had a great opportunity of founding a professorship; at Cambridge, if a sum of 200*l.* or 300*l.* could be guaranteed for a few years, a chair could be established; this was an opportunity for an Englishman to emulate the good works of American millionaires in coming to the aid of science. Not only in respect of teaching, but also in respect of ethnographical collections and accommodation for them, was Great Britain far behind other nations. (See p. 402.)

Geological Society, Feb. 6.—Mr. J. J. H. Teall, F.R.S., president, in the chair.—On the structure and affinities of the Rhætic plant *Naiadita*, by Miss Igerna B. J. Sollas, Newnham College, Cambridge. (Communicated by Prof. W. J. Sollas, F.R.S.) This plant, the remains of which are found in Gloucestershire, was considered to be a monocotyledon by Buckman, but a moss by Starkie Gardner. Material supplied by Mr. Seward and Mr. Wickes has given the authoress ground for the belief that *Naiadita* is an aquatic lycopod, and that it is the earliest recorded example of a fossil member of the Lycopodiaceæ, resembling in proportions and outward morphology the existing representatives of the group.—On the origin of the Dunmail Raise (Lake District), by Richard D. Oldham. The conclusion arrived at is that the gap of the Dunmail Raise was formed by a river, which flowed across the hills from north to south and cut down its channel *pari passu* with the elevation of the hills. The final victory of upheaval over erosion, whereby this river was divided into two separate drainage-systems and the barrier of the Dunmail Raise upheaved, may have synchronised with a diversion of the head-waters and consequent diminution of volume and erosive power. It is pointed out that this explanation comes into conflict with previously published theories of the origin of the drainage-system of the Lake District, inasmuch as the elevation postulated seems too slow to be explicable by the intrusion of a laccolite; and that the existence of a large river crossing the area of upheaval, and the maintenance of its character as an antecedent river-valley for a long period, show that the surface was originally a peneplain of subaërial denudation, and not a plain of marine sedimentation or erosion. From this it follows that the course of the main drainage-valleys may not have been determined by the original uplift, but, with the exception of those which are old river-valleys, whose direction of flow has been reversed on the northern side of the uplift, may have been formed by the cutting-back by erosion into the rising mass of high ground—in other words, that the principal valleys of the Lake District may be subsequent, not consequent, in origin.

MANCHESTER.

Literary and Philosophical Society, February 5.—Prof. Horace Lamb, F.R.S., president, in the chair.—Mr. T. Thorp and Dr. C. H. Lees were nominated as auditors for the current year.—Prof. Flux referred to the records of a recent report on water, gas and electricity undertakings, so far as they showed the rate of return on the capital invested in each case. The rates were grouped most thickly about 3 to 3½ per cent. for each class of enterprise, more closely in the case of water and, in a less degree, of gas than in the case of electricity. The total number of undertakings contributing to the result named was 1351, and the lowness of the figure representing the most frequent rate seemed rather striking.—Mr. Thomas Thorp mentioned that he had made further progress with an instrument designed to yield a pure monochromatic image of the sun, and had been able to obtain results of an encouraging nature. He hoped to be able to perfect the instrument in a short time and to exhibit it before the Society.—Dr. George Wilson read a paper, prepared by Mr. H. Noble and himself, entitled "Note on the construction of entropy diagrams from steam-engine indicator diagrams," showing how the effect of the clearance steam may be taken account of in the ordinary pressure-volume curve, thus enabling trials of different engines to give directly comparable results.—Mr. C. E. Stromeyer read a paper on the representation on a conical mantle of the areas on a sphere, in which he showed that the representation of points on the surface of a sphere on an enveloping cone, the distance of corresponding points on sphere and cone from the vertex of the cone being equal, gives a map on the developed cone the areas on which are proportional to those on the sphere.—The president announced at the close of the meeting that April 22 had been provisionally fixed for the delivery of the postponed Wilde Lecture by Dr. Metchnikoff.

EDINBURGH.

Mathematical Society, February 8.—Note on the cooling of a sphere in a finite mass of well-stirred liquid, by Dr. Peddie.—Some inequalities relating to arithmetic, geometric and other algebraic means, by R. F. Muirhead.

PARIS.

Academy of Sciences, February 11.—M. Fouqué in the chair.—On the generation of the hydrocarbons, by the metallic carbides, by M. Berthelot. From an examination of the thermochemical data concerning the metallic carbides, it is shown that the condition that an acetylide on treatment with water should give acetylene is that the difference between the heats of formation of the metallic hydrate and acetylide should be greater than 196·1 calories. This is the case with the carbides of the alkalies and the alkaline earths, but not for the acetylide of silver, and this latter compound is accordingly not decomposed by water. The cause of the production of a complicated gas mixture in some cases is also discussed from a thermochemical point of view.—Observations on the solutions of solid metals in mercury, and more generally in other fused metals, by M. Berthelot. It is pointed out that the use of the word solution to express the uniform distribution of a metal in mercury is not, strictly speaking, parallel to ordinary solution.—On precession, by M. O. Backlund. Correcting an error in a previous note.—On the specific heats of fluids, the elements of which are submitted to their mutual actions, by M. P. Duhem. It is shown that all the laws demonstrated in elementary thermodynamics for a fluid submitted to a normal and uniform pressure may be extended to a fluid the elements of which exercise any actions whatever upon each other, whether Newtonian or not.—On the photography of the solar corona in solar eclipses, by M. H. Deslandres. An account of the methods employed and the results obtained on the photography of the sun's corona during the solar eclipse of May 28, 1900.—On the theory of the satellites of Jupiter, by M. J. J. Landerer. A comparison of the results of observation with the theory of Souillart.—A new class of algebraic surfaces which admit of a continuous deformation and still remain algebraic, by M. D. Th. Egorov.—On certain transformations of Backlund, by M. Clairin.—On the theorem of Hugoniot and the theory of characteristic surfaces, by M. J. Coulon.—On a class of partial differential equations of the second order, by M. R. d'Adhémar.—On the linear partial differential forms of a system of simultaneous differential equations which are also the integrals of this system, by M. A. Buhl.—On circular arches, by M. Ribière.—On the diurnal variation of the magnetic declination, by M. Alfred Angot.—Calculation of the formula giving the law of the regular distribution of the horizontal component of the earth's magnetism in France on January 1, 1896, by M. E. Mathias.—An electric anemometer indicating at a distance, by M. Emmanuel Legrand. The motion of the vanes of the anemometer drives a small Gramme ring, the current from which is connected to a d'Arsonval galvanometer at a distance. The electromotive force produced is proportional to the velocity of rotation of the vane.—Telephonic communication by means of a wire stretched across the snow, by M. A. Ricco.—Remarks on the preceding communication, by M. Janssen.—The law of transparency of matter for the X-rays, by M. Louis Benoist. The specific opacity of a body to the X-rays is independent of its physical state, of the mode of atomic grouping and of the state of liberty or combination of the atoms. For X-rays sufficiently penetrating and homogeneous, the specific opacity of elements is a determinate and increasing function of the atomic weight, the two magnitudes being approximately proportional.—New researches on electric convection, by M. V. Crémieu. The author has repeated some of his original experiments with additional precautions, and considers it finally established that under the conditions of the experiments of Rowland and Himstedt electric convection produces no magnetic effect.—On musical impressions, by M. Firmin Larroque.—On the formation and decomposition of the acetals, by M. Marcel Delépine. The formation of acetals is a limited reaction, a state of equilibrium being set up between the alcohol, acetal, aldehyde and water. The results of experiments upon the limiting values of this reaction are given for methylal, dipropyl formal, erythrite diformal and mannite diformal.—On the elimination of methane from the atmosphere, by M. V. Urbain. Recent researches by MM. Muntz and Aubin and by M. Gautier on the amount of methane in the atmosphere, compared

"practical engineers or business men, thus bringing to bear on their teaching, not only the general education gained at school and their thorough knowledge of theoretical science, but also their practical experience of the workshop and business life."

These are but a few of the vital questions with which this valuable report is concerned. We heartily commend the volume to all who are interested in improving the home supply of technical education until it is not only on a level with that of Germany and Austria, but well in advance.

When we turn to the second of the reports, that concerned with the place in English secondary education of preparatory schools for boys, we are confronted with another stage in the preparation of the citizen for the duties of life. As every one knows, probably, the preparatory school undertakes the education, up to about fourteen, of the boy destined for our great public schools. Generally, after some five years at the public school, this fortunate son of well-to-do parents proceeds to either Oxford or Cambridge to continue his education. It is interesting to inquire as to the share science takes in the work of a preparatory school. It may be stated parenthetically that in a volume of 531 pp. only some sixteen pages are devoted to the teaching of mathematics and natural science together, though it is true nine of the sixteen are given to the latter.

It must be said at once that any science teaching at all in preparatory schools is the exception rather than the rule. To quote Mr. Archer Vassall, of Harrow, who deals with the subject in the official publication before us, "tentative efforts in scientific instruction have been made, and are still in progress at many of them"—and that is all that can be said. But there is nothing surprising about this. Since the sole function of the preparatory school is to prepare for the public school, those subjects only which are in demand in the second will be taught in the first, and, to quote Mr. Vassall again, "in public schools the teaching of science has only recently begun to take reasonable shape," a condition brought about by the regulations governing the award of University scholarships. So that to ensure an improved condition of things in the preparatory school men of science must bend their efforts towards securing reforms at Oxford and Cambridge.

Mr. Vassall's short article is chiefly concerned with a sketch of a suitable preparatory school course in natural science. In common with modern ideas he insists upon the need of individual practical work, and very properly urges that the study of science might well begin with what he calls "kindergarten physics." This mode of procedure has for some years been followed in higher grade boards schools, and in those other secondary schools which have adopted the syllabus of the Headmasters' Association. But we think Mr. Vassall is wrong in excluding chemistry from his preliminary course, for there are many excellent exercises which are in no way dangerous. Anyhow, a beginning has been made with science in preparatory schools, and if the masters will acquaint themselves with the results of experience in schools of other grades, we shall soon hear that science has gained for herself a more honourable place.

A. T. SIMMONS.

THE FIGURE OF THE EARTH.[1]

THE United States Coast and Geodetic Survey has just published a quarto volume containing an account of the transcontinental triangulations and measurements of an arc of the parallel in latitude 39°. It also has ready for publication the manuscript giving the result of an oblique arc in the eastern part of the United States. Both are contributions of great length and among the first of their kind in America.

Before entering upon the detail of the two arcs it may not be out of place to state that in order to obtain a measure of the dimensions of the earth, as represented by a spheroid, that is, by a surface generated by the rotation of an ellipse about its minor axis, it is essential that we should be in possession of at least two arcs or of an equivalent thereof. For combinations of two arcs of the meridian, their mean latitudes should differ widely; the same is true for the combination of two arcs of the parallel. We may also obtain an arc of the meridian with one of the parallel, but in every case the measures should be of considerable extent. Arcs of less than 5° (about 556 km., or 345 st. miles) would now be regarded as short ones. It has been stated that one of the arcs is an oblique arc, and as it possesses a great range of latitude and also of longitude and is supplied with a large number of astronomical measures, it is of itself sufficient for the deduction of values for the dimensions of the earth. Furthermore, it may be remarked that for any relatively small part of the earth's surface an osculating spheroid may be determined, as, for instance, was done for our oblique arc. Such a spheroid has the property that its surface is in best accord, as regards curvature, with the actual or physical one, the latter considered as a mathematical surface of equilibrium and generally known as geoid.

The definition of an osculating spheroid thus implies that the sum of the squares of the difference between the various astronomic and geodetic measures be a minimum. The mathematical treatment of the combination of the arc measures differs according to their nature, whether they are extended in a certain direction or whether large areas are covered, but in its generality it is necessarily laborious.

The salient points of the two arcs measured by the U. S. Coast and Geodetic Survey and the results reached may now be briefly stated. First, the arc of the parallel in latitude 39°.[1] It extends from Cape May, N.J., on the Atlantic coast, to Point Arena, Cal., on the Pacific coast, and ranges over 48° 46′ of longitude, with a linear development of about 4225 kilometres, or 2625 st. miles. The triangulation is supported by ten base lines with an aggregate length of 53½ st. miles, the longest or Yolo base being 10·9 miles in length, one half of these lines having a smaller probable error of measure than one part in a million. A characteristic of the triangulation is its rigidity imparted to it by quadrilaterals and other polygons. In crossing the Rocky Mountains, many of its sides exceed one hundred miles in length, and there is one side reaching to a length of 294 km., or 183 st. miles; the altitude of many of the stations is also considerable, reaching to 4300 metres, or 14 108 feet, in the case of Pike's Peak, and to 14,421 feet at Mount Elbert. All geometrical conditions subsisting in the triangulation are satisfied by adjustment, inclusive of the required accord of the base lines, so that the same length for any given line is found no matter from what line one may start. This involved much heavy work; for instance, the triangulation adjustment between the Salina and the El Paso base demanded the simultaneous solution of ninety-nine normal equations (with as many unknowns). In addition, the figures required the evolution of a correction to each of the two hundred and twenty-five observed directions.

Coming to the astronomical measures, we have distributed over or near the arc one hundred and nine latitude stations, occupied almost exclusively with zenith telescopes; there are, also, seventy-three azimuth stations, various methods having been used, and lastly we have twenty-nine telegraphically determined longitudes. These, of course, are of paramount importance for an arc of the parallel. There cannot be too many longitude stations in consequence of that great stumbling-block in geodesy, the local deflections of the vertical or plumb-line. These deflections of the zenith from a normal direction have been divided into two groups—those which are regional or manifest themselves with marked common features over thousands of square miles, and those which are quite local and greatly depend upon the surface features immediately surrounding them.

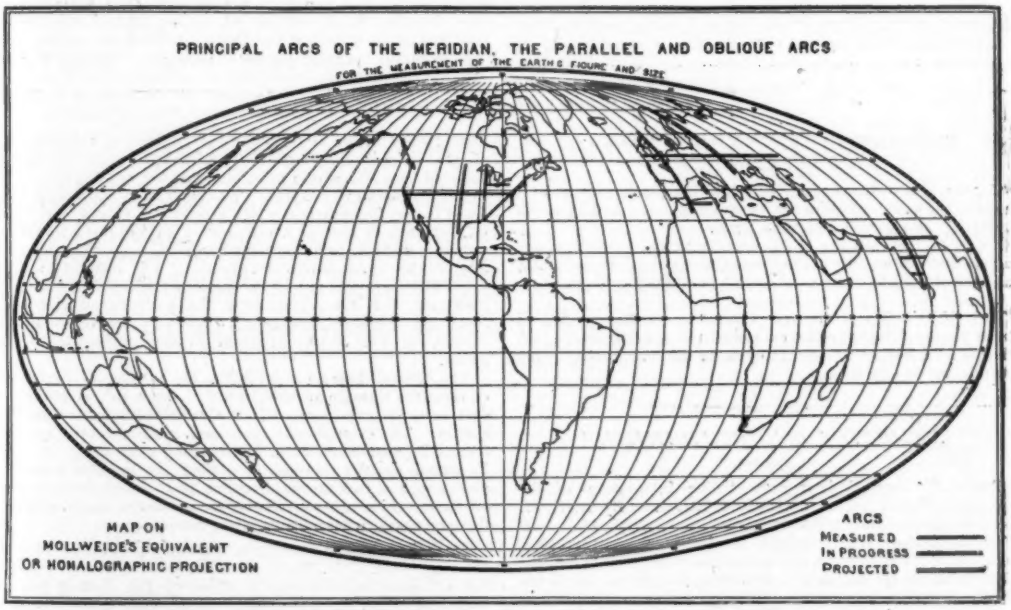
These deflections, even in level countries, average about 2·5″; but in mountainous regions this deflection is greatly surpassed. Thus we find for deviation of the plumb-line at Patmos Head station 12″ to the north, at Colorado Springs 25″ to the west, at Salt Lake City about 17″, and at Ogden about 15″ to the east, at Genoa Station, Nev., nearly 29″ to the west, the quantities depending to some extent on the spheroid of reference; but their amount and direction are obviously well accounted for by the position of known attracting masses. In connection with this, continental attraction may manifest itself and be recognised by the astronomical amplitude of the longitudes of extreme stations of a long arc being in excess of the corresponding geodetic amplitude. The matter cannot be further pursued here in detail, but it may suffice to state that the average curvature of the equipotential surface of the geoid along the parallel of 39°

[1] Abridged from a paper on recent contributions by the United States Coast and Geodetic Survey to our knowledge of the earth's shape and size, by Mr. C. A. Schott, in the *National Geographic Magazine*, New York.

[1] U. S. Coast and Geodetic Survey; H. S. Pritchett, Superintendent. The Transcontinental Triangulation and the American Arc of the Parallel. By C. A. Schott, Assistant, Coast and Geodetic Survey, Washington, D.C., 1900.

approaches for about four-sevenths of the arc from its eastern end closely to that of the Clarke spheroid; whereas, for the remaining three-sevenths, or for the region across the Rocky Mountains to the Pacific, the curvature comes more nearly to that of the Besselian spheroid. In the published paper two tables are given containing the results needed for combination with any other arc and, in conclusion, some preliminary rough combinations of American arcs are presented; all of which point to a reference spheroid of larger dimensions than those of the Besselian and are in favour of continuing the use of Clarke for reference.

The second arc under consideration extends from Calais, Me., in the north-east and opposite the Canadian boundary, to the Gulf of Mexico, and terminates at New Orleans, La. It is known as the Eastern Oblique Arc of the United States. Its length is 2612 km., or 1623 statute miles; its difference of latitude is 15° 1′, and of longitude 22° 47′. The general direction is therefore favourable, and the length ample to secure fair results for an osculating spheroid. In the main the triangulation follows the Appalachian chain of mountains; in Western North Carolina and Eastern Tennessee it bifurcates, leaving an oval space between the two branches. The length of sides



depends upon six base lines, and in general the development is closely accommodated to the hypsometric and other natural conditions along the course. It includes among its stations the two highest points in the eastern part of the United States, viz. Mount Washington, N.H., rising to about 1920 metres, or 6300 feet, and Mount Mitchell, N.C., rising to about 2038 metres, or 6687 feet.

The adjustment of the whole triangulation is effected precisely as explained in the use of the arc of the parallel; the small reduction to the sea-level of the observed horizontal directions, on account of the altitudes sighted, was only applied when exceeding 0·05″. The principal labour of adjustment was demanded by the necessity of bringing into accord the measured lengths of the Fire Island, the Massachusetts and the Epping base lines, and fulfilling the geometrical conditions of the intervening net of triangles. This demanded the satisfying of fifty-seven conditions and involved the simultaneous solution of an equal number of normal equations and the working out of 131 corrections of observed directions. Of astronomical measures we have seventy-one latitute stations, seventeen longitude stations, and fifty-six azimuth stations, tolerably well distributed over the whole extent of the arc. The latitudes, as were those of the arc of parallel, were corrected for height of station or curvature of the vertical and for variation of pole according to Dr. Chandler's and Dr. Albrecht's researches. The same scrutiny as before had been extended to the deflections of the vertical, both regional and local. Partly on account of avoiding unnecessary labour, but principally on account of the crowding together of astronomical stations in certain very limited localities, and all of them, therefore, partaking of the deflections characteristic of this area, the total number of astronomical stations admitted into the final equations for the determination of the best spheroid were thirty-six for latitude, fourteen for longitude, and thirty-four for azimuth, or eighty-four conditions in all.

These eighty-four differences between the astronomical and geodetic results constitute the data needed for a new determination of a spheroid; next the functional relations between the positions of these stations upon the reference spheroid to the earth's equatorial radius and to the compression of the polar axis had to be established.

The final normal equations contain, therefore, four unknown quantities, viz. the correction to the meridional deflection of the vertical at the initial or reference station of the oblique arc; second, the corrections to the deflection of the vertical, in the plane of the prime vertical, at the same place; third, correction to the equatorial radius of the reference spheroid; and, last, the correction to its compression.

In the combination of conditional equations arising from observations of a different nature, the question of their relative weights must be considered. In the present case, four assumptions were made and the consequent normal equations solved, viz. for equal weights, for weights one-half, one-third and one-fourth to the azimuth equations, the latter being necessarily inferior to the equations derived from latitudes and longitudes. A comparison of these four results showed that it was of small consequence which of these hypotheses was finally adopted, since the corrections to the equatorial radius of the reference spheroid were practically the same for any of these hypotheses, and nearly the same could be said of the resulting compressions. The weight one-third to each of the azimuth equations was finally decided upon, and the resulting dimensions of an osculating spheroid were found to be:—Equatorial radius, 6,378,157 ± 90 metres; compression, 1/304·5 ± 1·9. The equatorial radius, therefore, differs but 49 metres from Clarke's value of 1866 adopted on the Survey, while the Besselian value is apparently too small by 809 metres. On the other hand, the compression or the ratio of the difference of the equatorial and polar semi-axes to the former is in favour

of Bessel's spheroid, of which the compression is 1/299·2; that is, one more closely approaching a sphere.

In the present state of our knowledge there is no reason to suppose that the curvature of the northern part of America differs any more from that of a general spheroid derived from arcs of all kinds so far measured than local ones in either hemisphere differ among themselves. A comparison of a number of such locally adopted spheroids will bring to evidence the local deformities in the shape of the earth's equilibrium surface and furnishes the geodesists endless material for the study of the earth's actual figure.

The manuscript concludes with a comparative table of the dimensions of several spheroids which of late have come more into prominence. It is as follows :—

Spheroid of	Equatorial radius, a, in metres.	Polar semi-axis b, in metres.	$a-b$.	Compression $(a-b)/a$.
Bessel, 1841. From ten arcs of the meridian and total amplitude 50° 34′	6,377,397	6,356,079	21,318	1/299·15±3·15
Clarke, 1858. Special spheroid for surface of Great Britain and Ireland; range of latitude 12°, the same in longitude; seventy-five astronomic stations	6,378,494±90	6,355,746	22,748	1/280·4±8·3
Clarke, 1866. From five meridional arcs, of total amplitude 76° 35′	6,378,206	6,356,584	21,622	1/295·0
Clarke, 1880. From five meridional arcs and longitudinal measures, total amplitude 88° 59·8′ (equatorial degrees)	6,378,249	6,356,515	21,734	1/293·5
United States Coast and Geodetic Survey, 1900. Eastern oblique arc of the United States; total length, 23° 31′, and eighty-four astronomic stations	6,378,157±90	6,357,210	20,947	1/304·5±1·9
Harkness, 1891. From "The Solar Parallax and Related Constants," Washington, 1891, p. 138. From a variety of sources	6,377,972±125	6,356,727±99	21,245	1/300·2±3·0

N.B.—The ± indicates probable errors.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—A valuable collection of Greek papyri from Oxyrhyncus and the Fayûm has been presented to the University library by the Egypt Exploration Fund.

Dr. A. C. Haddon, F.R.S, University lecturer in ethnology, and professor of zoology in the Royal College of Science, Dublin, has been elected to a junior fellowship at Christ's College.

THE King's Speech to the Commons at the opening of Parliament on Thursday last contained the announcement that "Legislation will be proposed to you for the amendment of the law relating to education."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 7.—"The Integration of the Equations of Propagation of Electric Waves." By A. E. H. Love, F.R.S.

The equations of propagation of electric waves, through a dielectric medium, involve two vector quantities, which may be taken to be the electric force and the magnetic force. Both the vectors are circuital; and the several components of them satisfy the partial differential equation of wave propagation, viz. $\ddot{\phi} = c^2\nabla^2\phi$, c being the velocity of radiation.

Owing to the circuital relations, certain known solutions of the partial differential equation of wave propagation are not available, for representing the components of the vectors. A very general system of *particular* solutions, which are available for this purpose, is obtained. These include solutions corresponding to two types of sources of electric radiation:—The sources of one type are similar to infinitesimal Hertzian vibrators, being related in the same way to an axis, but the dependence of the emitted radiation on time is arbitrary; the sources of the other type are obtained therefrom by interchanging the *rôles* of the electric and magnetic forces.

The general integrals of the equations would express the values of the vectors, at one place and time, in terms of their values, at other places and times. To find such integrals, we require (1) sets of particular solutions, which tend to become infinite, in definite ways, in the neighbourhood of chosen points; (2) a theorem of reciprocity, connecting the values, on any chosen surface, of two sets of solutions; (3) the limiting form, assumed by the theorem of reciprocity, when the solutions of one system have the assigned character of infinity at a given point. The solutions required for the first step are among those already found; the theorem of reciprocity is obtained by a modification of the process by which the fundamental equations can be deduced from the Action principle; and the limiting form of the theorem is found by adapting a process due to Kirchhoff. The result is that the radiation which arrives at a chosen point may be regarded as due to a distribution of imagined sources of radiation upon an arbitrary closed surface, separating the point from all the actual sources of radiation. The imagined sources are of the two types previously specified; and the directions of their axes, and the intensities of the radiation sent out from them, are determined simply and directly by the values, on the surface, of the vectors involved in the propagation of the waves.

The general theorem is applied to the problem of the passage of radiation through an aperture, and the result is utilised to determine the rate of decay of the vibrations of a condensing system. The example of a condenser, with concentric spherical conducting surfaces, the outer conducting sheet being perforated by a small circular aperture, is worked out in detail; and the results suggest that the maintenance of the vibrations depends on the screening action of the outer conductor rather than on the largeness of the capacity of the condenser.

Anthropological Institute, February 4.—Annual General Meeting.—Mr. C. H. Read, president, in the chair.—On a ballot the following were elected to office for the ensuing year:—President: Prof. A. C. Haddon, F.R.S. Vice-presidents: A. J. Evans, W. Gowland, Prof. G. B. Howes. Hon. Treasurer: A. L. Lewis. Hon. Secretary: J. L. Myres. Council: Sir T. H. Holdich, Sir C. E. Peek, Messrs. G. M. Atkinson, H. Balfour, W. Crooke, Prof. D. J. Cunningham, W. L. H. Duckworth, R. W. Felkin, H. O Forbes, J. G. Garson, E. S. Hartland, T. V. Holmes, E. F. im Thurn, A. Keith, R. B. Martin, M.P., R. H. Pye, E. G. Ravenstein, Prof. W. Ridgeway, W. H. R. Rivers and F. C. Shrubsall. After reading and discussion of the reports of the treasurer and council, the retiring president proceeded to give his address After alluding to the death of Her Majesty Queen Victoria and paying a tribute to Lieut.-General Pitt-Rivers, an ex-president of the Institute, Prof. Max Müller, Miss Kingsley and other distinguished Fellows who had been removed by death, he went on to call attention to the progress made by anthropology, more especially in the British Empire, during the past year. A joint memorial of the Folk-lore Society and the Institute had been presented to the Government, urging the theoretical and practical importance of an inquiry into the status of native races in South Africa. In India, in combination with the census, a scheme for a partial ethnographical survey had been called into existence, over the working of which the Hon. H. H. Risley would preside. He hoped that in England we should soon have chairs of anthropology at all the important teaching

centres; Birmingham had a great opportunity of founding a professorship; at Cambridge, if a sum of 200*l.* or 300*l.* could be guaranteed for a few years, a chair could be established; this was an opportunity for an Englishman to emulate the good works of American millionaires in coming to the aid of science. Not only in respect of teaching, but also in respect of ethnographical collections and accommodation for them, was Great Britain far behind other nations. (See p. 402.)

Geological Society, Feb. 6.—Mr. J. J. H. Teall, F.R.S., president, in the chair.—On the structure and affinities of the Rhætic plant *Naiadita*, by Miss Igerna B. J. Sollas, Newnham College, Cambridge. (Communicated by Prof. W. J. Sollas, F.R.S.) This plant, the remains of which are found in Gloucestershire, was considered to be a monocotyledon by Buckman, but a moss by Starkie Gardner. Material supplied by Mr. Seward and Mr. Wickes has given the authoress ground for the belief that *Naiadita* is an aquatic lycopod, and that it is the earliest recorded example of a fossil member of the Lycopodiaceæ, resembling in proportions and outward morphology the existing representatives of the group.—On the origin of the Dunmail Raise (Lake District), by Richard D. Oldham. The conclusion arrived at is that the gap of the Dunmail Raise was formed by a river, which flowed across the hills from north to south and cut down its channel *pari passu* with the elevation of the hills. The final victory of upheaval over erosion, whereby this river was divided into two separate drainage-systems and the barrier of the Dunmail Raise upheaved, may have synchronised with a diversion of the head-waters and consequent diminution of volume and erosive power. It is pointed out that this explanation comes into conflict with previously published theories of the origin of the drainage-system of the Lake District, inasmuch as the elevation postulated seems too slow to be explicable by the intrusion of a laccolite; and that the existence of a large river crossing the area of upheaval, and the maintenance of its character as an antecedent river-valley for a long period, show that the surface was originally a peneplain of subaërial denudation, and not a plain of marine sedimentation or erosion. From this it follows that the course of the main drainage-valleys may not have been determined by the original uplift, but, with the exception of those which are old river-valleys, whose direction of flow has been reversed on the northern side of the uplift, may have been formed by the cutting-back by erosion into the rising mass of high ground—in other words, that the principal valleys of the Lake District may be subsequent, not consequent, in origin.

MANCHESTER.

Literary and Philosophical Society, February 5.—Prof. Horace Lamb, F.R.S., president, in the chair.—Mr. T. Thorp and Dr. C. H. Lees were nominated as auditors for the current year.—Prof. Flux referred to the records of a recent report on water, gas and electricity undertakings, so far as they showed the rate of return on the capital invested in each case. The rates were grouped most thickly about 3 to 3½ per cent. for each class of enterprise, more closely in the case of water and, in a less degree, of gas than in the case of electricity. The total number of undertakings contributing to the result named was 1351, and the lowness of the figure representing the most frequent rate seemed rather striking.—Mr. Thomas Thorp mentioned that he had made further progress with an instrument designed to yield a pure monochromatic image of the sun, and had been able to obtain results of an encouraging nature. He hoped to be able to perfect the instrument in a short time and to exhibit it before the Society.—Dr. George Wilson read a paper, prepared by Mr. H. Noble and himself, entitled "Note on the construction of entropy diagrams from steam-engine indicator diagrams," showing how the effect of the clearance steam may be taken account of in the ordinary pressure-volume curve, thus enabling trials of different engines to give directly comparable results.—Mr. C. E. Stromeyer read a paper on the representation on a conical mantle of the areas on a sphere, in which he showed that the representation of points on the surface of a sphere on an enveloping cone, the distance of corresponding points on sphere and cone from the vertex of the cone being equal, gives a map on the developed cone the areas on which are proportional to those on the sphere.—The president announced at the close of the meeting that April 22 had been provisionally fixed for the delivery of the postponed Wilde Lecture by Dr. Metchnikoff.

EDINBURGH.

Mathematical Society, February 8.—Note on the cooling of a sphere in a finite mass of well-stirred liquid, by Dr. Peddie.—Some inequalities relating to arithmetic, geometric and other algebraic means, by R. F. Muirhead.

PARIS.

Academy of Sciences, February 11.—M. Fouqué in the chair.—On the generation of the hydrocarbons by the metallic carbides, by M. Berthelot. From an examination of the thermochemical data concerning the metallic carbides, it is shown that the condition that an acetylide on treatment with water should give acetylene is that the difference between the heats of formation of the metallic hydrate and acetylide should be greater than 196·1 calories. This is the case with the carbides of the alkalies and the alkaline earths, but not for the acetylide of silver, and this latter compound is accordingly not decomposed by water. The cause of the production of a complicated gas mixture in some cases is also discussed from a thermochemical point of view.—Observations on the solutions of solid metals in mercury, and more generally in other fused metals, by M. Berthelot. It is pointed out that the use of the word solution to express the uniform distribution of a metal in mercury is not, strictly speaking, parallel to ordinary solution.—On precession, by M. O. Backlund. Correcting an error in a previous note.—On the specific heats of fluids, the elements of which are submitted to their mutual actions, by M. P. Duhem. It is shown that all the laws demonstrated in elementary thermodynamics for a fluid submitted to a normal and uniform pressure may be extended to a fluid the elements of which exercise any actions whatever upon each other, whether Newtonian or not.—On the photography of the solar corona in solar eclipses, by M. H. Deslandres. An account of the methods employed and the results obtained on the photography of the sun's corona during the solar eclipse of May 28, 1900.—On the theory of the satellites of Jupiter, by M. J. J. Landerer. A comparison of the results of observation with the theory of Souillart.—A new class of algebraic surfaces which admit of a continuous deformation and still remain algebraic, by M. D. Th. Egorov.—On certain transformations of Backlund, by M. Clairin.—On the theorem of Hugoniot and the theory of characteristic surfaces, by M. J. Coulon.—On a class of partial differential equations of the second order, by M. R. d'Adhémar.—On the linear partial differential forms of a system of simultaneous differential equations which are also the integrals of this system, by M. A. Buhl.—On circular arches, by M. Ribière.—On the diurnal variation of the magnetic declination, by M. Alfred Angot.—Calculation of the formula giving the law of the regular distribution of the horizontal component of the earth's magnetism in France on January 1, 1896, by M. E. Mathias.—An electric anemometer indicating at a distance, by M. Emmanuel Legrand. The motion of the vanes of the anemometer drives a small Gramme ring, the current from which is connected to a d'Arsonval galvanometer at a distance. The electromotive force produced is proportional to the velocity of rotation of the vane.—Telephonic communication by means of a wire stretched across the snow, by M. A. Ricco.—Remarks on the preceding communication, by M. Janssen.—The law of transparency of matter for the X-rays, by M. Louis Benoist. The specific opacity of a body to the X-rays is independent of its physical state, of the mode of atomic grouping and of the state of liberty or combination of the atoms. For X-rays sufficiently penetrating and homogeneous, the specific opacity of elements is a determinate and increasing function of the atomic weight, the two magnitudes being approximately proportional.—New researches on electric convection, by M. V. Crémieu. The author has repeated some of his original experiments with additional precautions, and considers it finally established that under the conditions of the experiments of Rowland and Himstedt electric convection produces no magnetic effect.—On musical impressions, by M. Firmin Larroque.—On the formation and decomposition of the acetals, by M. Marcel Delépine. The formation of acetals is a limited reaction, a state of equilibrium being set up between the alcohol, acetal, aldehyde and water. The results of experiments upon the limiting values of this reaction are given for methylal, dipropyl formal, erythrite diformal and mannite diformal.—On the elimination of methane from the atmosphere, by M. V. Urbain. Recent researches by MM. Muntz and Aubin and by M. Gautier on the amount of methane in the atmosphere, compared

with those of Boussingault, show that the proportion of this gas has not increased. Hence, like carbonic acid, it would appear to be eliminated in some way. By an extensive series of experiments, the author shows that this elimination is effected by plants.—Actions of the esters of the monobasic fatty acids upon the mixed organo-magnesium compounds, by M. V. Grignard. The use of magnesium has the advantage over the Wagner-Satzeff reaction not only in its simplicity and increased yield, but also in increased generality. Thus ethyl formate and magnesium ethyl bromide gives a 73 per cent. yield of diethylcarbinol; with isoamyl bromide of magnesium and ethyl formate the formate of diisoamylcarbinol is obtained. Diisobutylcarbinol can be prepared by the analogous reaction.—On the absorption of light by the indophenols, by MM. P. Bayrac and C. Camichel.—On the acid and alcoholic combinations of phenylcarbazide, or the urea of phenylhydrazine, by M. P. Cazeneuve.—Ketones from wood tar, by M. A. Behal. The ketone, dimethylcyclohexonone, has been isolated from the neutral oil of wood tar. Its constitution was determined by means of its oxidation products, potassium permanganate giving only acetic acid and α-levulinic acid.—On dibromo- and diiodobutane: a new synthesis of adipic acid, by M. l'abbé J. Hamonet.—Comparison between the nucleated and non-nucleated red blood corpuscle, by M. R. Quinton. From the point of view of osmosis the nucleated red blood corpuscle differs in its behaviour from the non-nucleated corpuscle, inasmuch as an equilibrium is attained in the former case with urea in solution, but not in the latter.—Blastoderm without an embryo, by M. Gustave Loisel.—Action of the total pressure on the chlorophyll assimilation, by M. Jean Friedel. The diminution of the total pressure tends to favour assimilation. When air containing carbonic acid is rarefied, the assimilation passes first through a minimum and then through a maximum.—On the tuberculisation of the potato, by M. Noel Bernard. It has been previously shown by the author that in certain plants the formation of tubers from the buds is a consequence and a symptom of the infection of the roots by endophytic fungi. Experiments are now given for the potato, confirming these views, and it is pointed out that if this conclusion is exact, it should be possible, by a rational culture of the potato, to increase the size and yield of the tubers.—On a new group of very basic rocks, by M. A. Lacroix.—New observations on the glacial period in the southern Carpathians, by M. E. de Martonne.—The transgressions and the regressions of the secondary seas in the basin of the Aquitaine, by M. Ph. Glangeaud.—Contribution to the study of subterranean waters. Isochronochromatic curves, by M. Félix Marboutin.

DIARY OF SOCIETIES.

THURSDAY, FEBRUARY 21.

ROYAL SOCIETY, at 4.30.—An Attempt to Estimate the Vitality of Seeds by an Electrical Method: Dr. Waller, F.R.S.—On a New Manometer, and on the Law of the Pressure of Gases between 1·5 and ·01 millimetres of Mercury: Lord Rayleigh, F.R.S.—(1) An Investigation of the Spectra of Flames resulting from Operations in the Open Hearth and "Basic" Bessemer Processes; (2) The Mineral Constituents of Dust and Soot from various Sources: Prof. Hartley, F.R.S., and Hugh Ramage.—Notes on the Spark Spectra of Silicon as rendered by Silicates: Prof. Hartley, F.R.S.

LINNEAN SOCIETY, at 8.—On the Affinities of *Æluropus melanoleucus*, Alph. Milne Edw.: Prof. E. Ray Lankester, F.R.S., and R. Lydekker, F.R.S.—Étude d'une espèce nouvelle de Lépapèdes: M. A. Gruvel.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—If the discussion on Mr. Mordey's paper is closed, the following paper will be read:—The Electrical Power Bill of 1900: Before and After: W. L. Madgen.

CHEMICAL SOCIETY, at 8.—(1) Isomeric Hydrindamine Mandelates and Phenylchloracethydrindamides; (2) Isomeric Benzylhydrindamine bromocamphorsulphonates and some Salts of *d-l*-Hydrindamine: F. Stanley Kipping and H. Hall.—Condensation of Phenols with Esters of the Acetylene Series. IV. Benzo-γ-pyrone and its Homologues: S. Ruhemann and H. W. Bausor.—Constitution of Bromocamphoric Anhydride and Camphanic Acid: A. Lapworth and W. H. Lenton.—The Action of Acetylchlor- and Acetylbrom-aminobenzenes on Amines and Phenylhydrazine: F. D. Chattaway and K. J. P. Orton.

FRIDAY, FEBRUARY 22.

ROYAL INSTITUTION, at 9.—Metals as Fuel: Sir W. Roberts-Austen, F.R.S.

PHYSICAL SOCIETY, at 5.—How Air subjected to X-Rays loses its Discharging Property, and how it Discharges Electricity: Prof. Emilio Villari.—(1) On the Propagation of Cusped Waves and their Relation to the Primary and Secondary Focal Lines; (2) On Cyanine Prisms, and a New Method of Exhibiting Anomalous Dispersion: Prof. R. W. Wood.

INSTITUTION OF CIVIL ENGINEERS at 8.—Automatic Coupling: J. L. Cridlan.

SATURDAY, FEBRUARY 23.

ROYAL INSTITUTION, at 3.—Sound and Vibrations: Lord Rayleigh, F.R.S.

ESSEX FIELD CLUB (Essex Museum of Natural History Stratford), at 6 30.—Recent Work in Molluscan Morphology: Prof. G. B. Howes, F.R.S.

MONDAY, FEBRUARY 25.

ROYAL INSTITUTION, at 3.—Practical Mechanics: Prof. J. A. Ewing, F.R.S.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Some Aspects of South American Geography: Colonel G. E. Church.

SOCIETY OF ARTS, at 8.—The Bearings of Geometry on the Chemistry of Fermentation: W. J. Pope.

INSTITUTE OF ACTUARIES, at 5.30.—The Increase of Cancer: R. Teece.

TUESDAY, FEBRUARY 26.

ROYAL INSTITUTION, at 3.—The Cell as the Unit of Life: Dr. A. Macfadyen.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Rotatory Process of Cement Manufacture: W. H. Stanger and Bertram Blount.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Notes from Five Years' Work with X-Rays: W. Webster.

WEDNESDAY, FEBRUARY 27.

SOCIETY OF ARTS, at 8.—The Outlook for the World's Timber Supply: Dr. W. Schlich.

THURSDAY, FEBRUARY 28.

ROYAL SOCIETY, at 4.30.

SOCIETY OF ARTS, at 4.30.—Railways and Famine: Horace Bell.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Conclusion of discussion on Mr. Madgen's paper.—Followed, if possible, by Cables: M. O'Gorman.

FRIDAY, MARCH 1.

ROYAL INSTITUTION, at 9.—Enamels: H. H. Cunynghame.

GEOLOGISTS' ASSOCIATION, at 8.—The Post-Pliocene Non-Marine Mollusca of the South of England: A. S. Kennard and B. B. Woodward.—The Pleistocene Fauna of West Wittering, Sussex: J. P. Johnson.

SATURDAY, MARCH 2.

ROYAL INSTITUTION, at 3.—Sound and Vibrations: Lord Rayleigh.

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